Simulations of extreme dry and wet rainy seasons of West Africa and their trend in future climates using a simple vegetation model within ECHAM5

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Universität zu Köln

MWF NRW.

Bundesministerium für Bildung und Forschung

universitätbonn

outlook

- Motivation / IMPETUS

- IMPETUS Model Chain (from global to local scale)

- SVege - Simple Vegetation Model

- results

  - present day climate
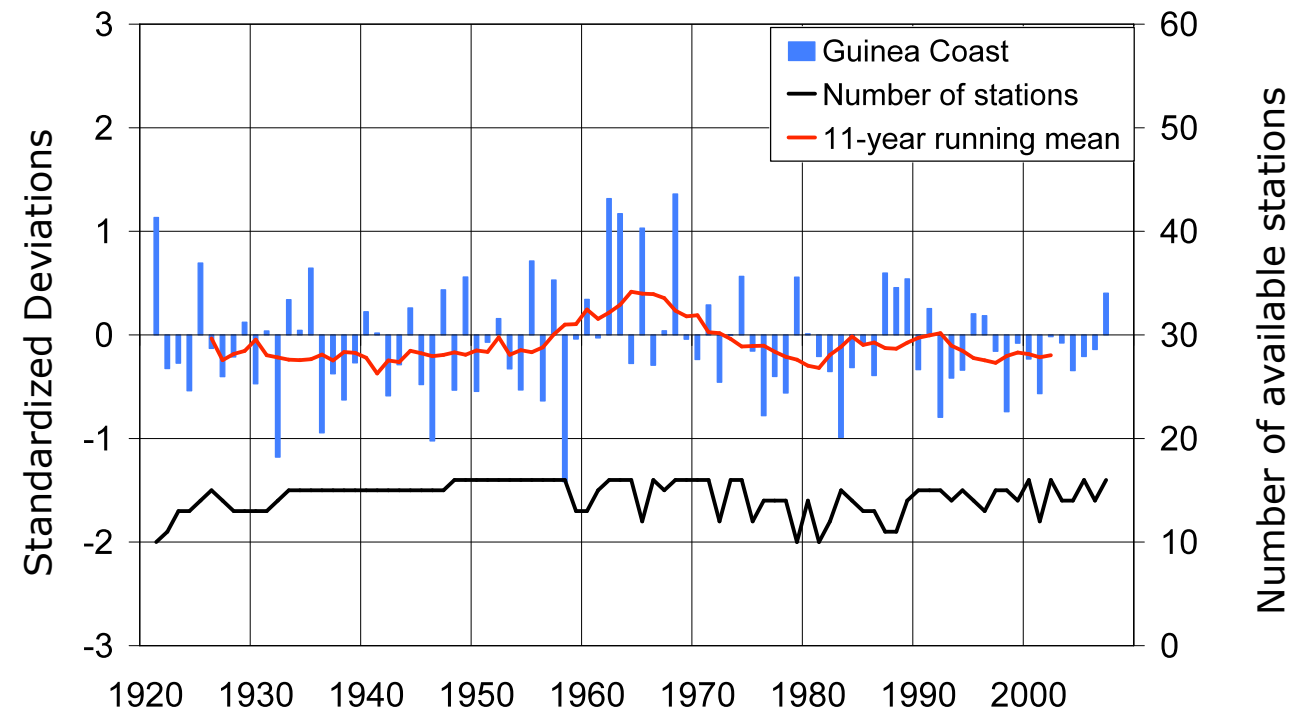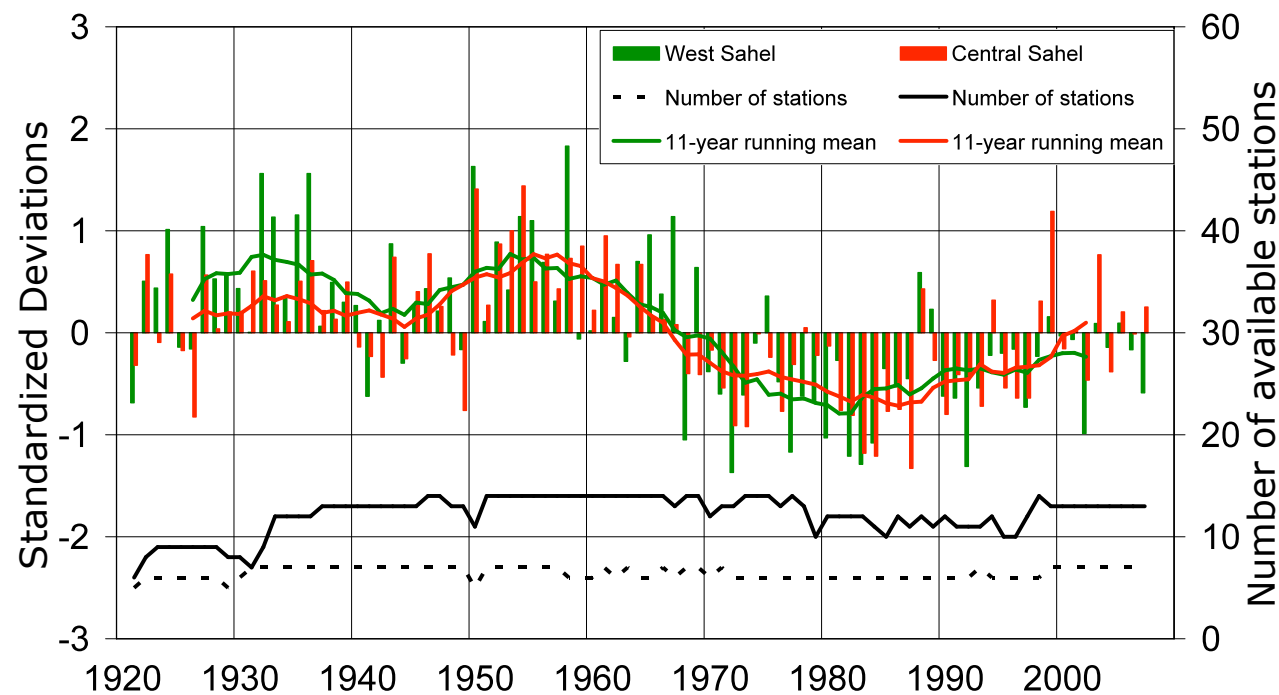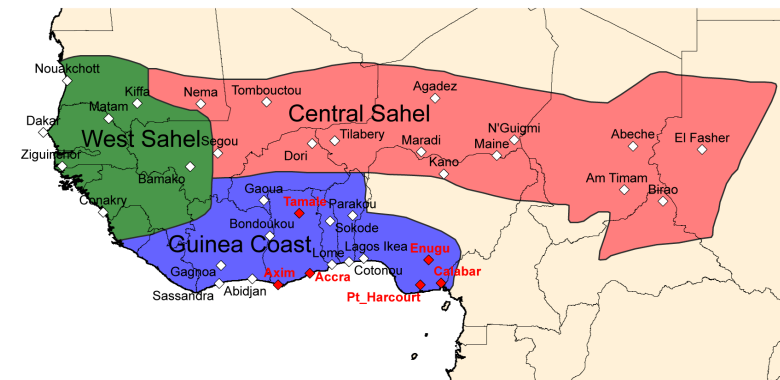
  - future trends

- conclusion

outlook

Motivation
Rainfall Variability in Tropical West Africa (1921-2007)

$$Index = \frac{\overline{\sum_{JJAS} RR_i} - CLIM_{JJAS}}{\sigma_{JJAS}}$$

Base period: 1950-1990

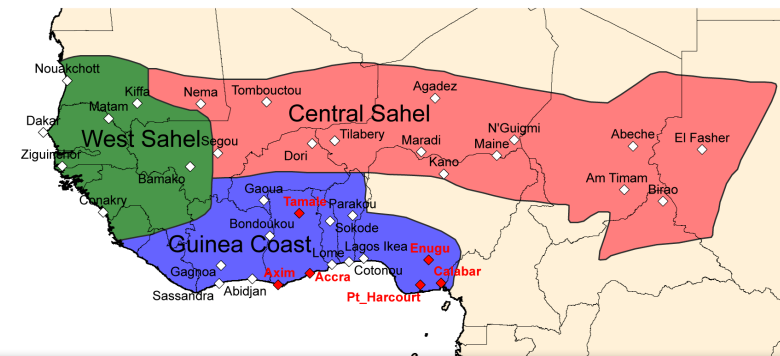Figures: courtesy of A. Fink and S.Kotthaus,
IGM, University of Cologne, Germany

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what about ...

    ... future trends

    ... socioeconomic impacts

    ... food security

    ...

?

Figures: courtesy of A. Fink and S.Kotthaus,
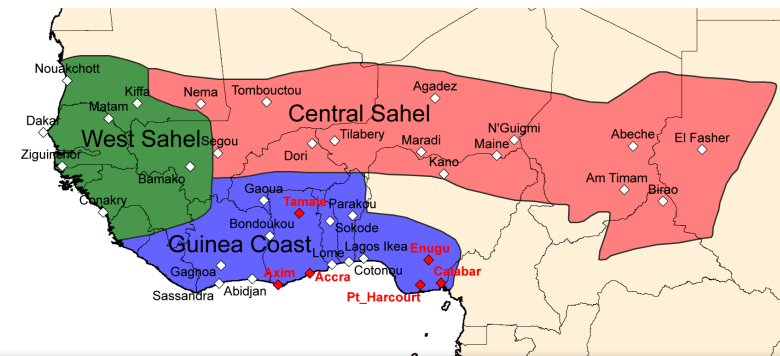IGM, University of Cologne, Germany

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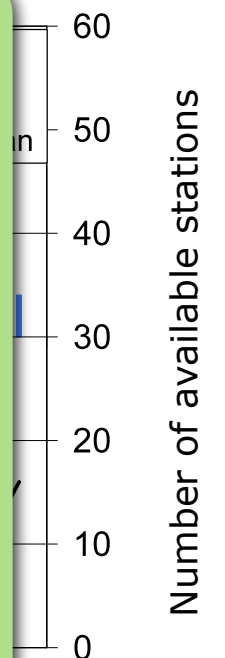
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what about ...

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 ...

Figures: courtesy of A. Fink and S.Kotthaus, IGM, University of Cologne, Germany

IMPETUS
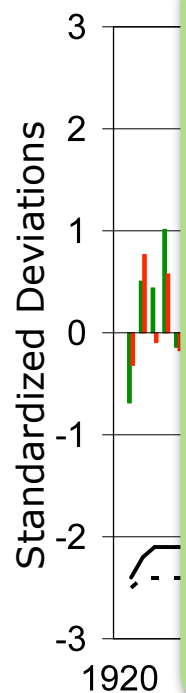
- **An Integrated Approach to the Efficient Management of Scarce Water Resources in West Africa**

- **The Catchments of the Ouémé-River (Benin) and the Wadi Drâa (Morocco) are investigated**

- **Relations to the climates of Europe might exist via complex atmosphere-ocean interactions in the area of the tropical/ subtropical and north Atlantic ocean**

- **West Africa: most pronounced inter-decadel variability of climate**

- **for more details see: http://www.impetus.uni-koeln.de**

Challenges
concerning future climate trends

- after the IPCC 4AR there is no clear projection for West African precipitation trends (increase / decrease)

  ➡ it is necessary to put some light on it

- what about changes in the intensity and variability of the West African Monsoon on different time scales

- what about Monsoon onset and brakes in future climate

Project Plan

- **1st Phase:** Data Acquisition and Modeling *(2000-2003)*

- **2nd Phase:** Development of Scenarios and Problem Clusters *(2003-2006)*

- **3rd Phase:** Transfer and Application: Capacity Building and Spatial Decision Support Systems *(2006-2009)*

Project Plan

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IMPETUS model chain

- model chain for a
  statistic - dynamical down-
  scaling of global projections
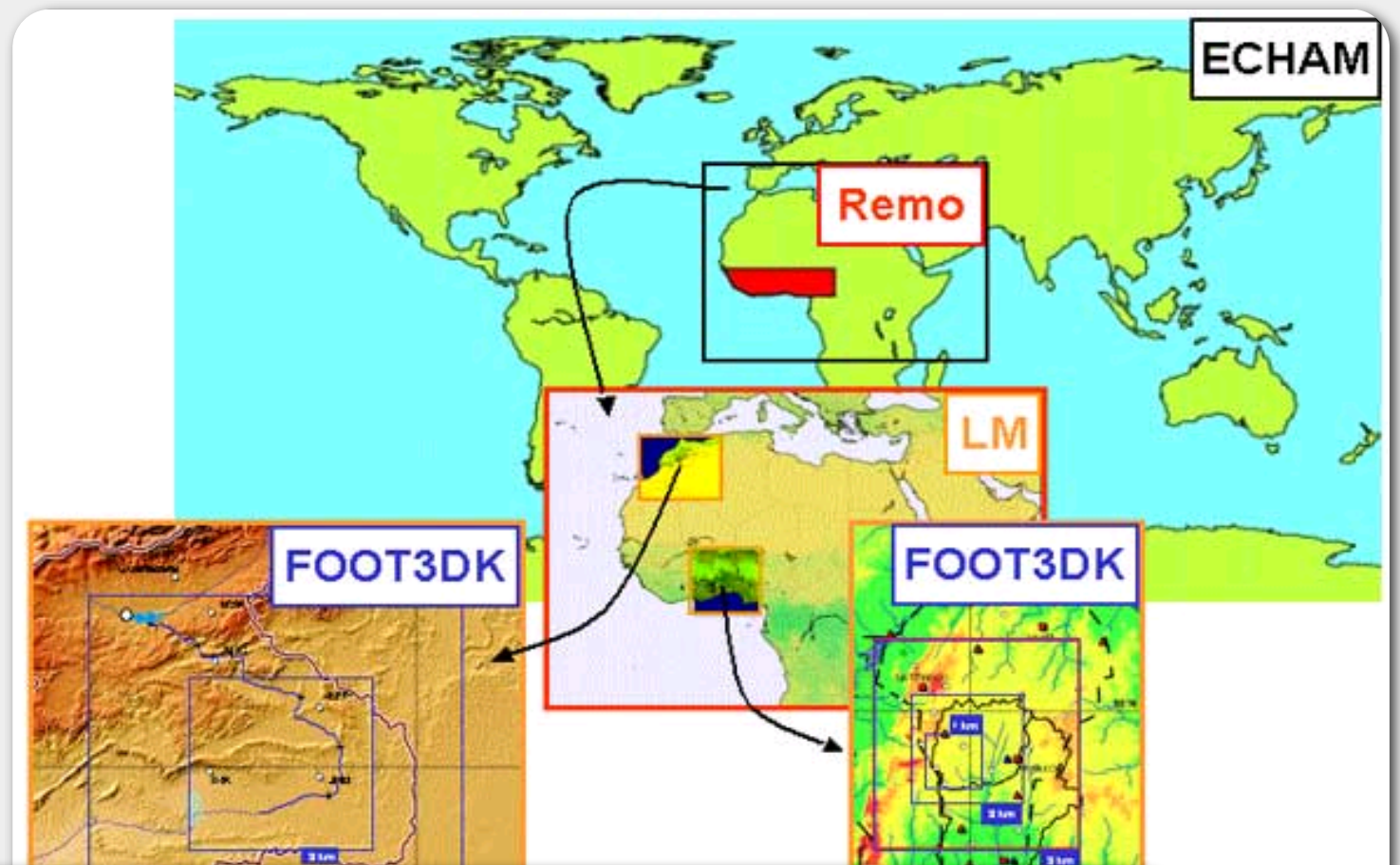 down to key-region

- starting from 250 km
  down to 3 km

  consider as many aspects
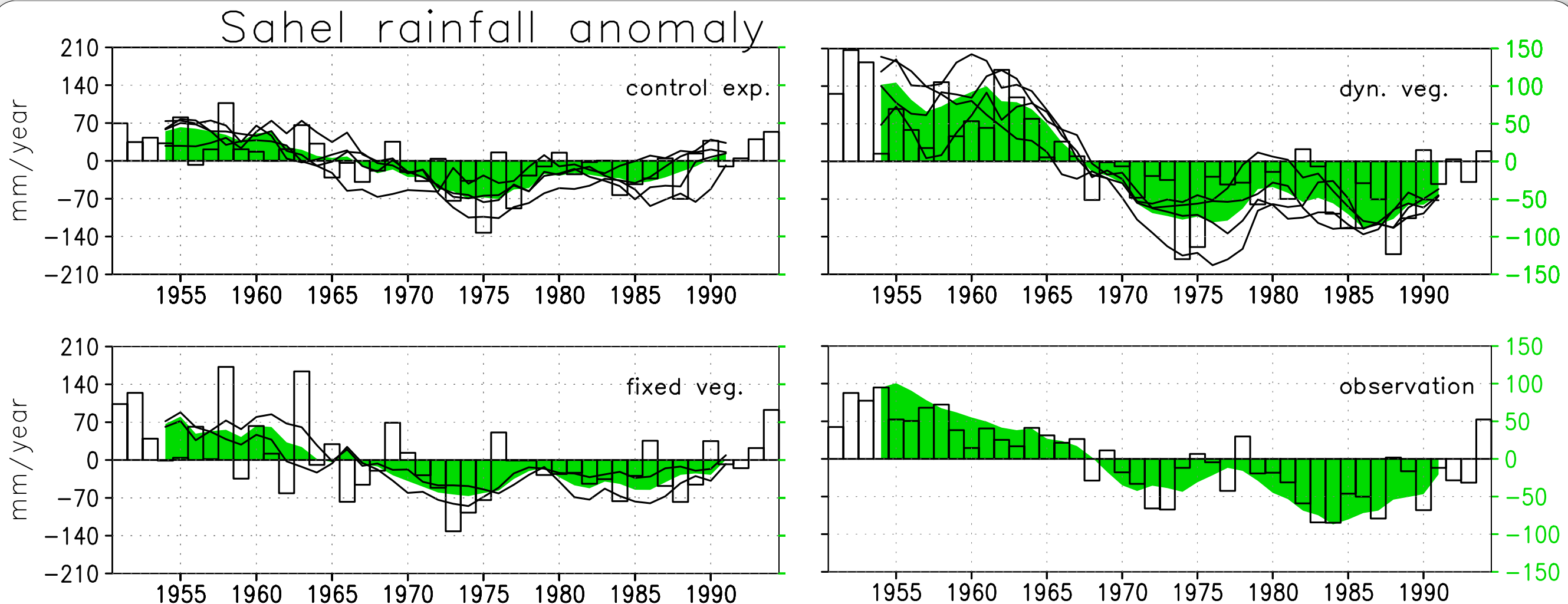 as possible to get best
  boundary conditions for
  nested models
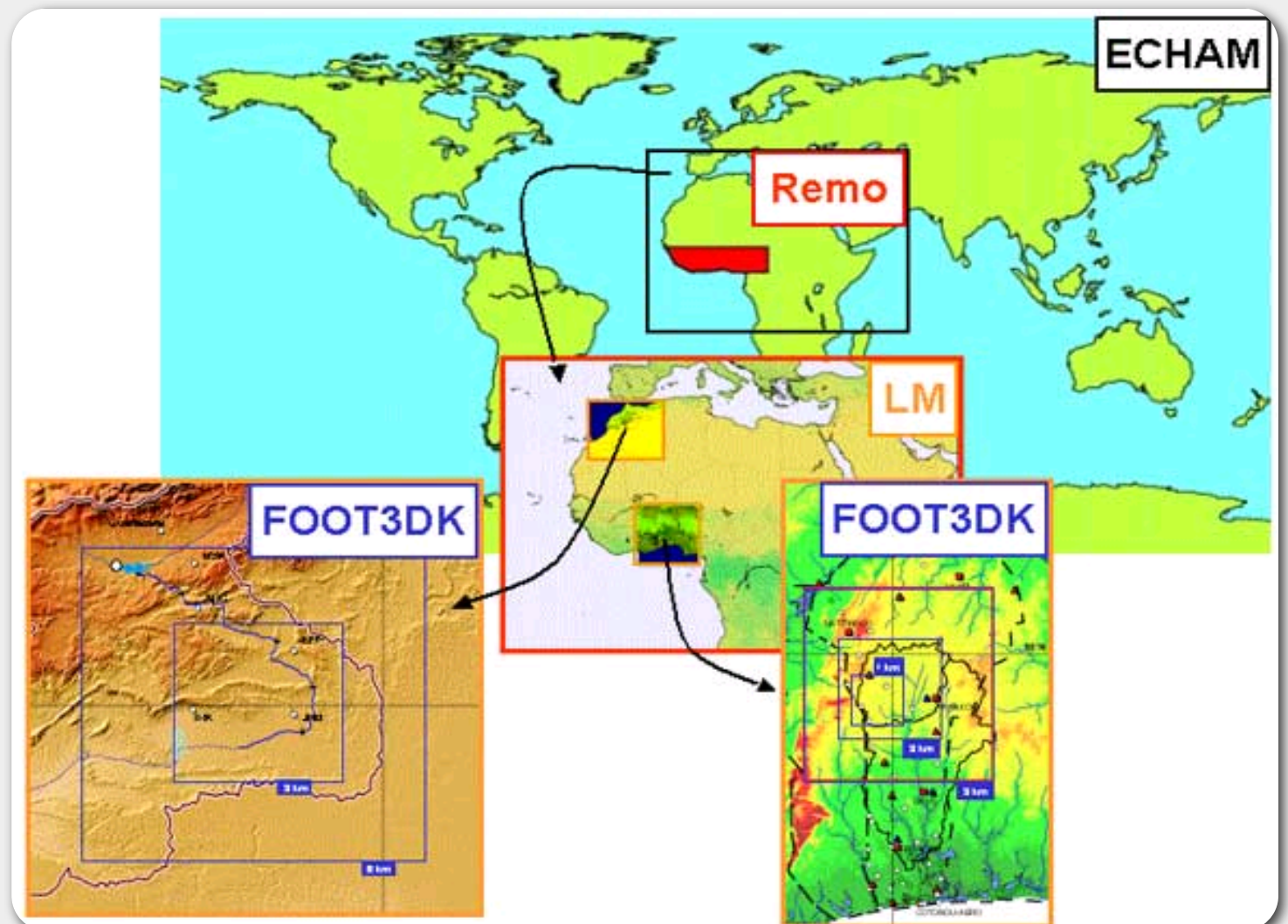
IMPETUS model chain

- model chain for a statistic - dynamical down-scaling of global projections down to key-region

- starting from 250 km down to 3 km

  consider as many aspects as possible to get best boundary conditions for ne

➡️ include biosphere: **S**imple **Vege**tation model (SVege)

Motivation: using SVege within E4

Sahel rainfall anomaly
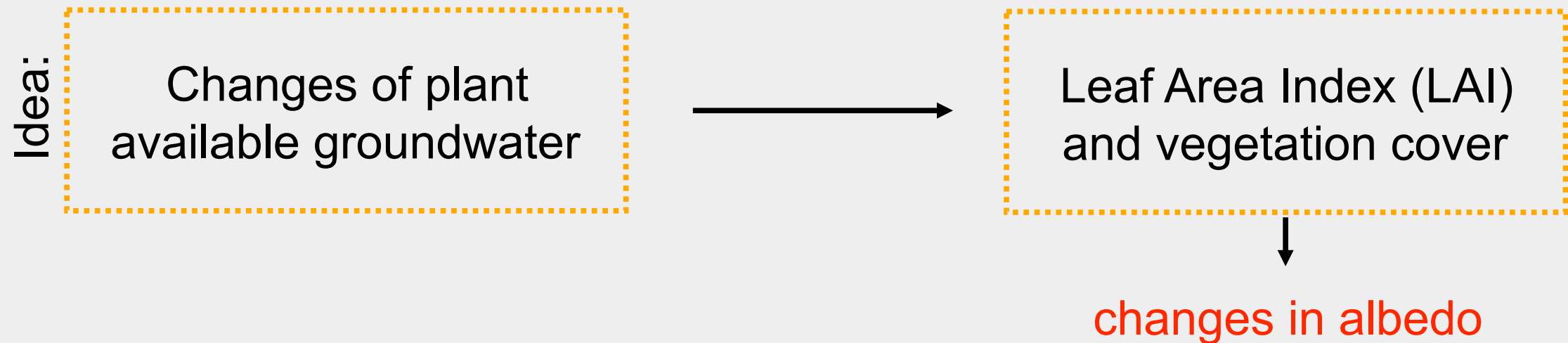control exp.

fixed veg.

Schnitzler et al. (2001)
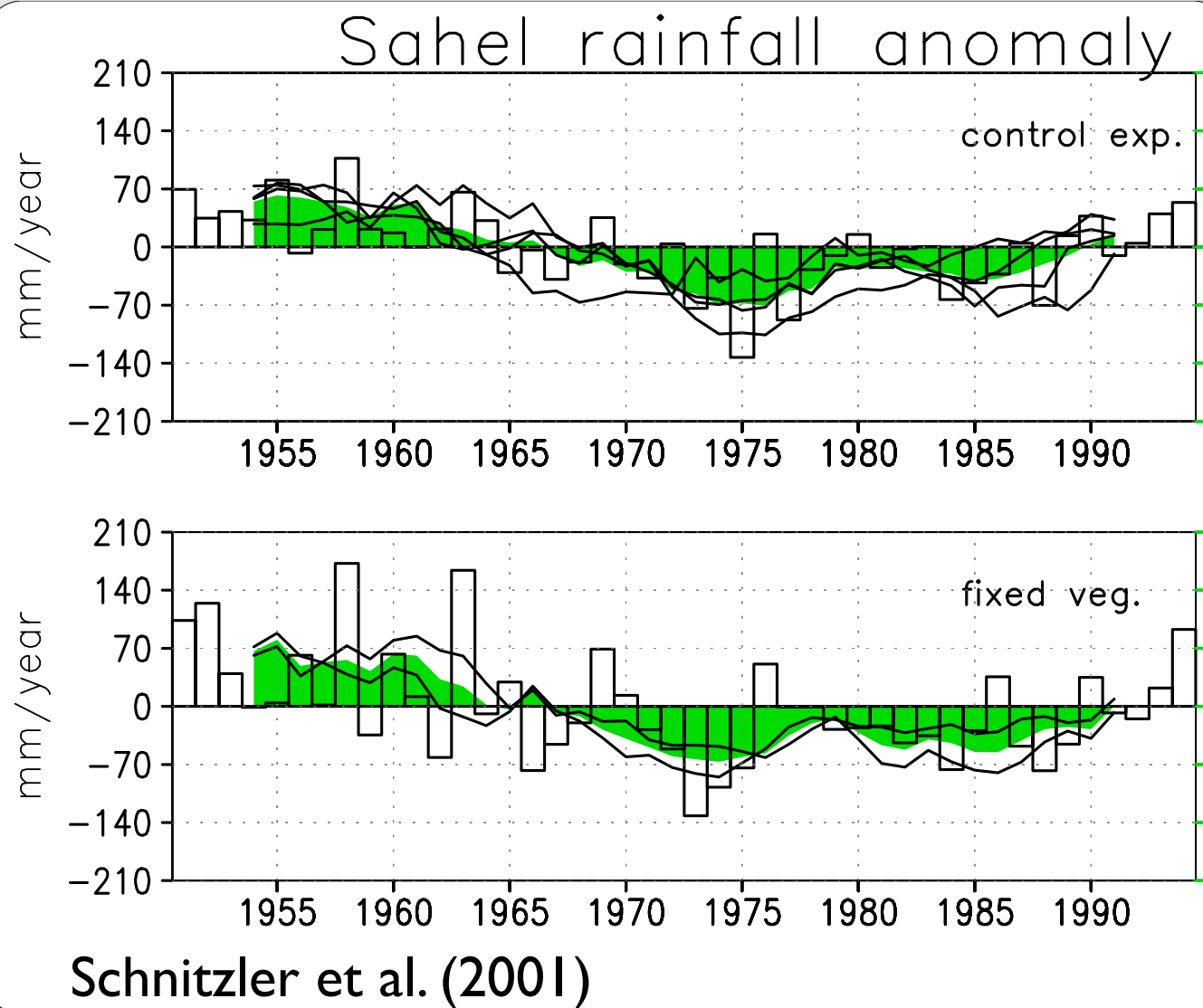
Base period for anomaly: 1951-1994

Motivation: using SVege within E4

Sahel rainfall anomaly

control exp.

dyn. veg.

fixed veg.

observation

Schnitzler et al. (2001)

Base period for anomaly: 1951-1994

SVege: Simple Vegetation Model
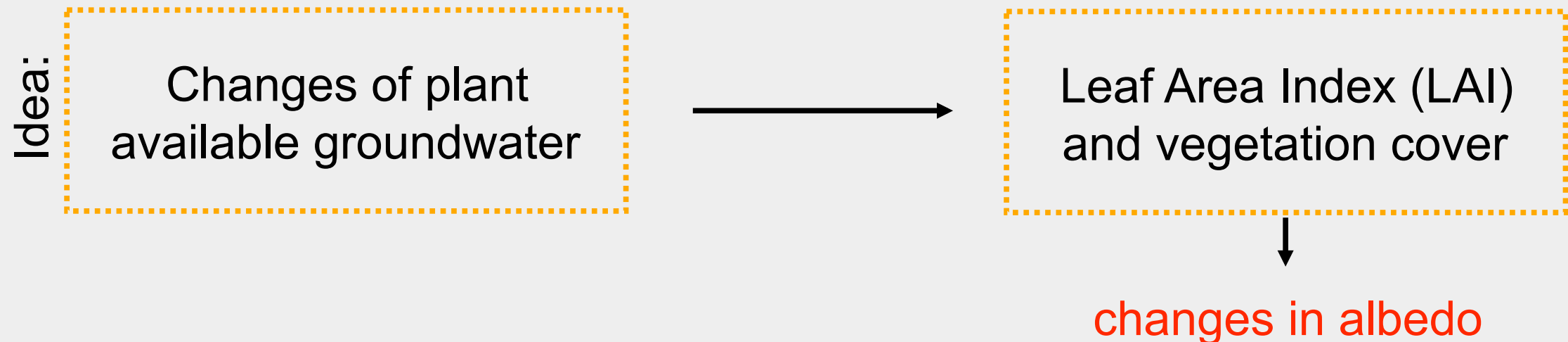
Idea:

Changes of plant available groundwater ⟶ Leaf Area Index (LAI) and vegetation cover

⟶ changes in albedo

SVege: Simple Vegetation Model

Idea:

┌─────────────────────────┐   ┌─────────────────────────┐
│   Changes of plant   │   ────────────▶   │ Leaf Area Index (LAI) │
│ available groundwater │   │ and vegetation cover   │
└─────────────────────────┘   └─────────────────────────┘
                                                            │
                                                            ▼
                                                  changes in albedo

SVege includes no dependencies of vegetation growth upon temperature and duration of sunshine:

- Implemented for non-boreal areas (40°N to 40°S)

- Outside this domain the albedo values from the **L**and **S**urface **P**arameters - dataset (LSP, Steffan Hagemann 2002) are used (climatological mean)

- No other changes in land surface parameters are simulated (e. g. roughness length)

SVege: Simple Vegetation Model
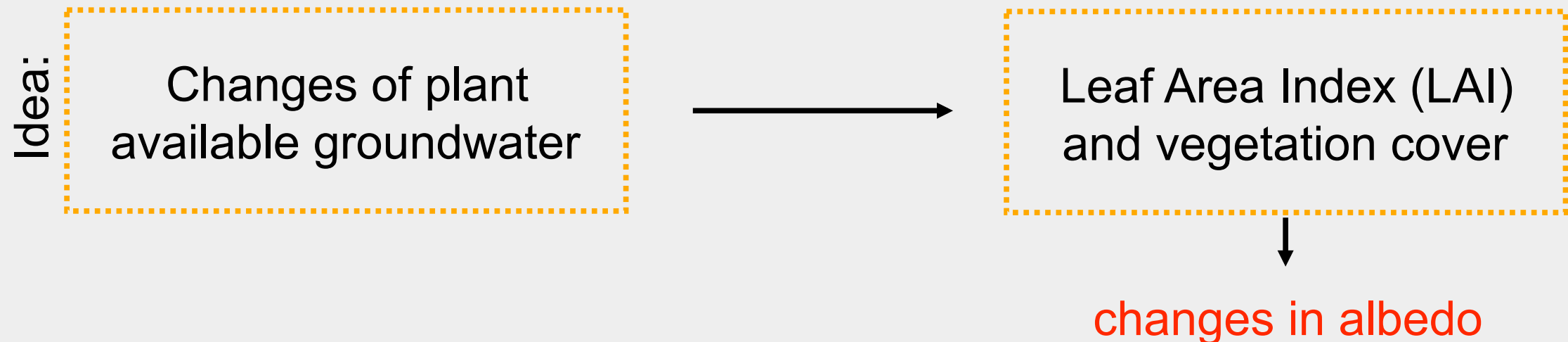
Idea:

Changes of plant available groundwater	→	Leaf Area Index (LAI) and vegetation cover

↓

changes in albedo

SVege includes no dependencies of vegetation growth upon temperature and duration of sunshine:

- Implemented for non-boreal areas (40°N to 40°S)

our update:

only grid boxes with a vegetation cover higher than 15% are considered

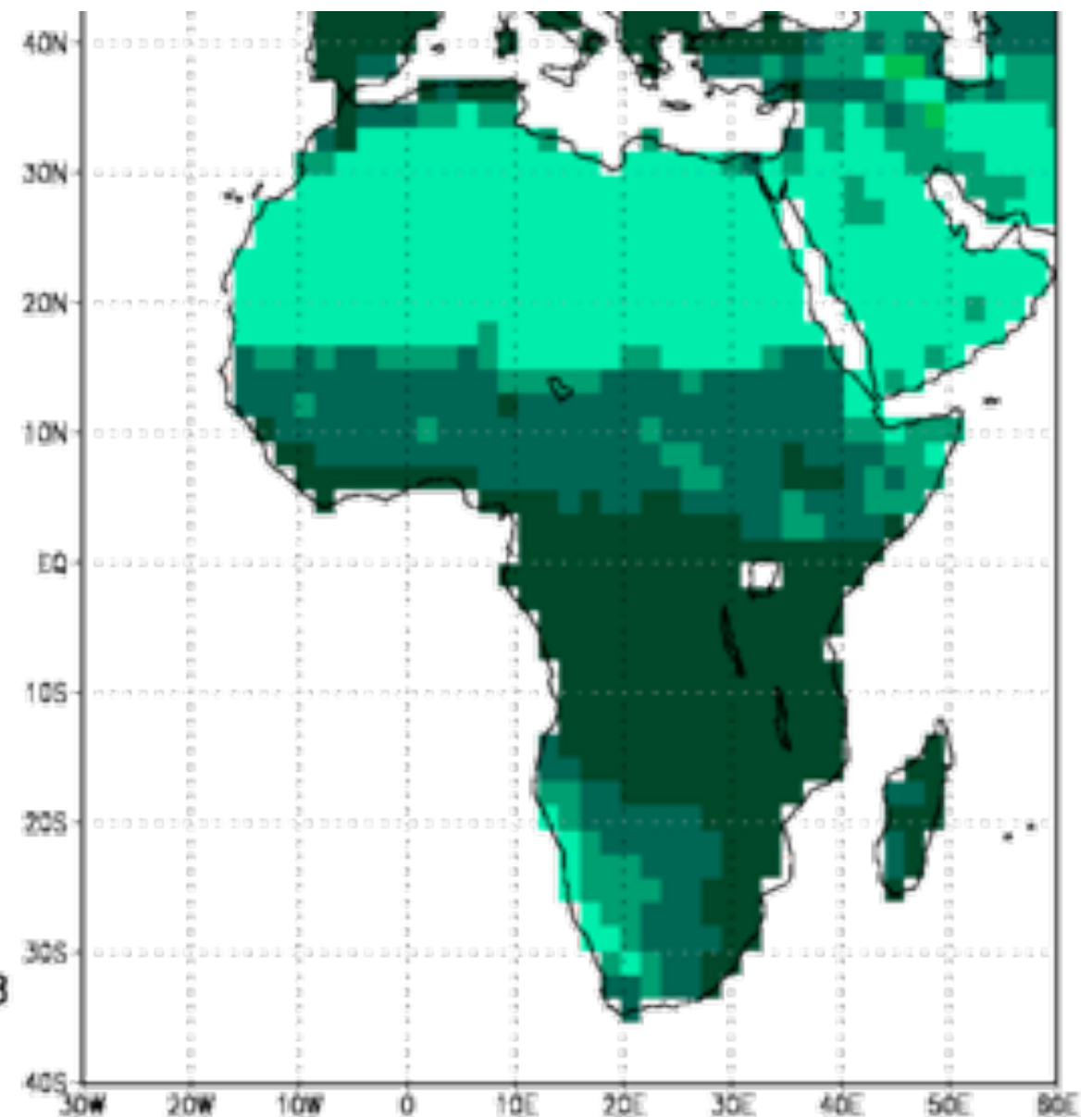simulated (e. g. roughness length)

SVege: „Cologne version"

standard albedo of ECHAM5
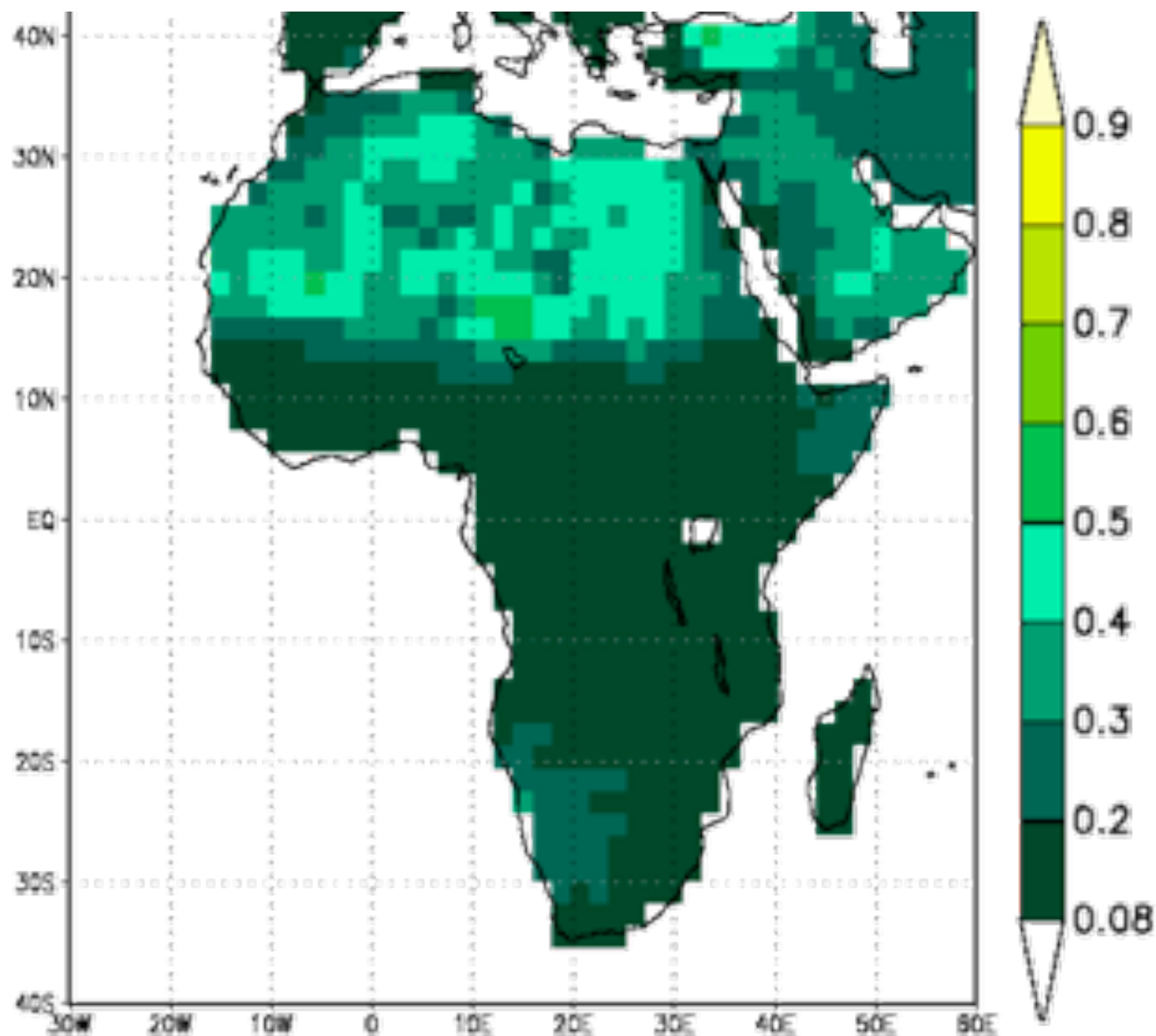
SVege: „Cologne version"
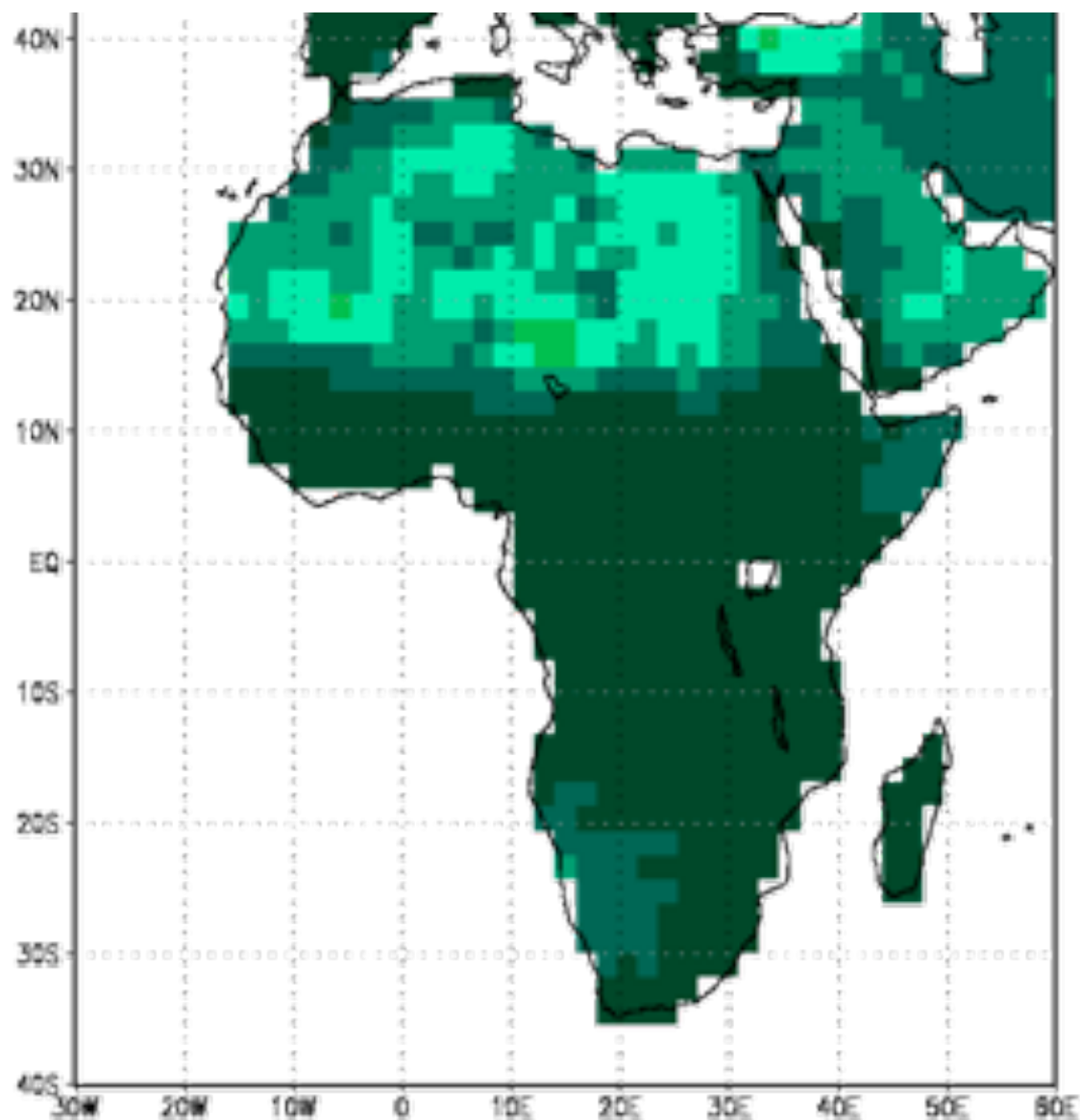
standard albedo of ECHAM5   standard version of SVege

SVege: „Cologne version"

standard albedo of ECHAM5
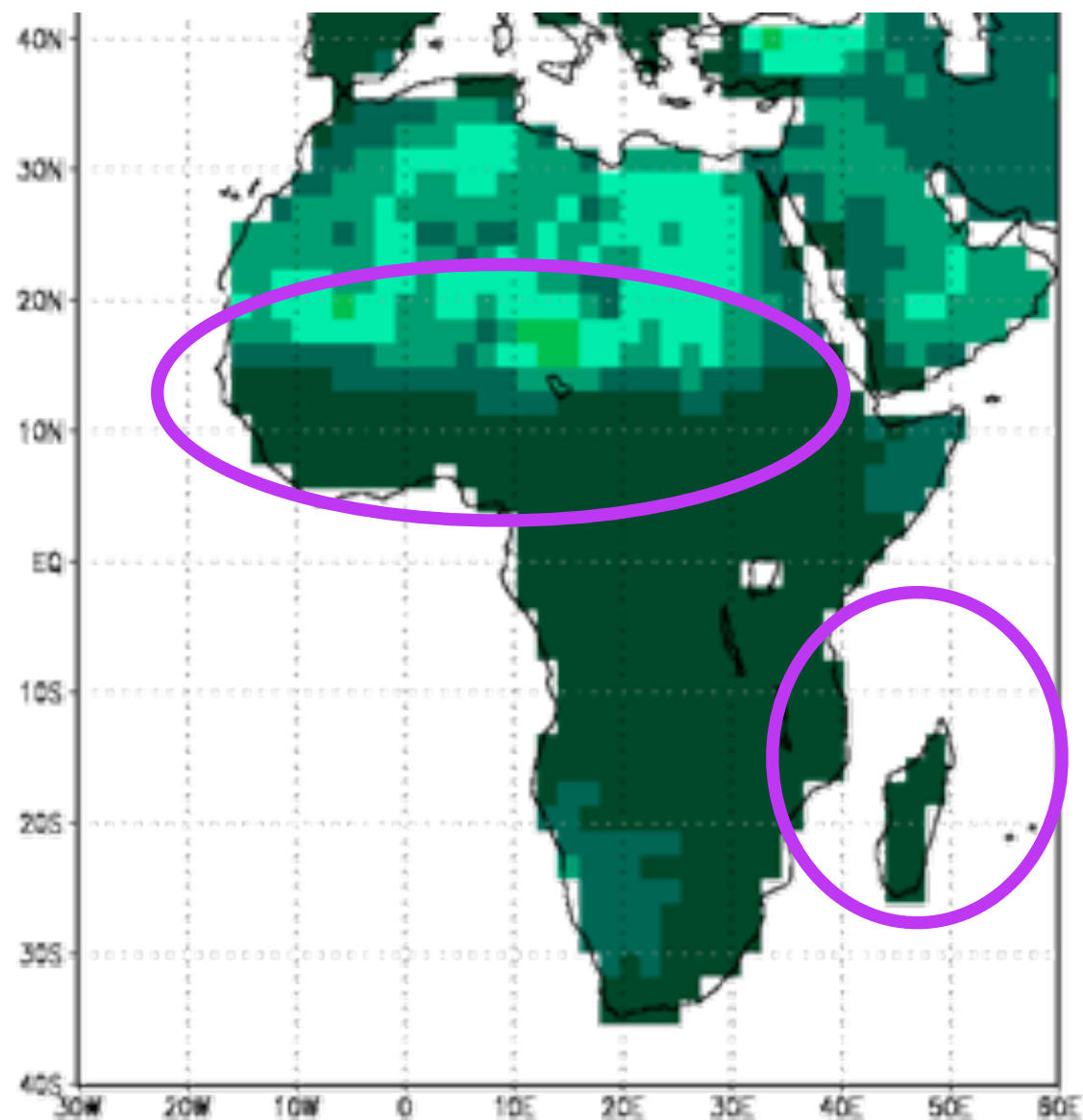
Cologne Version
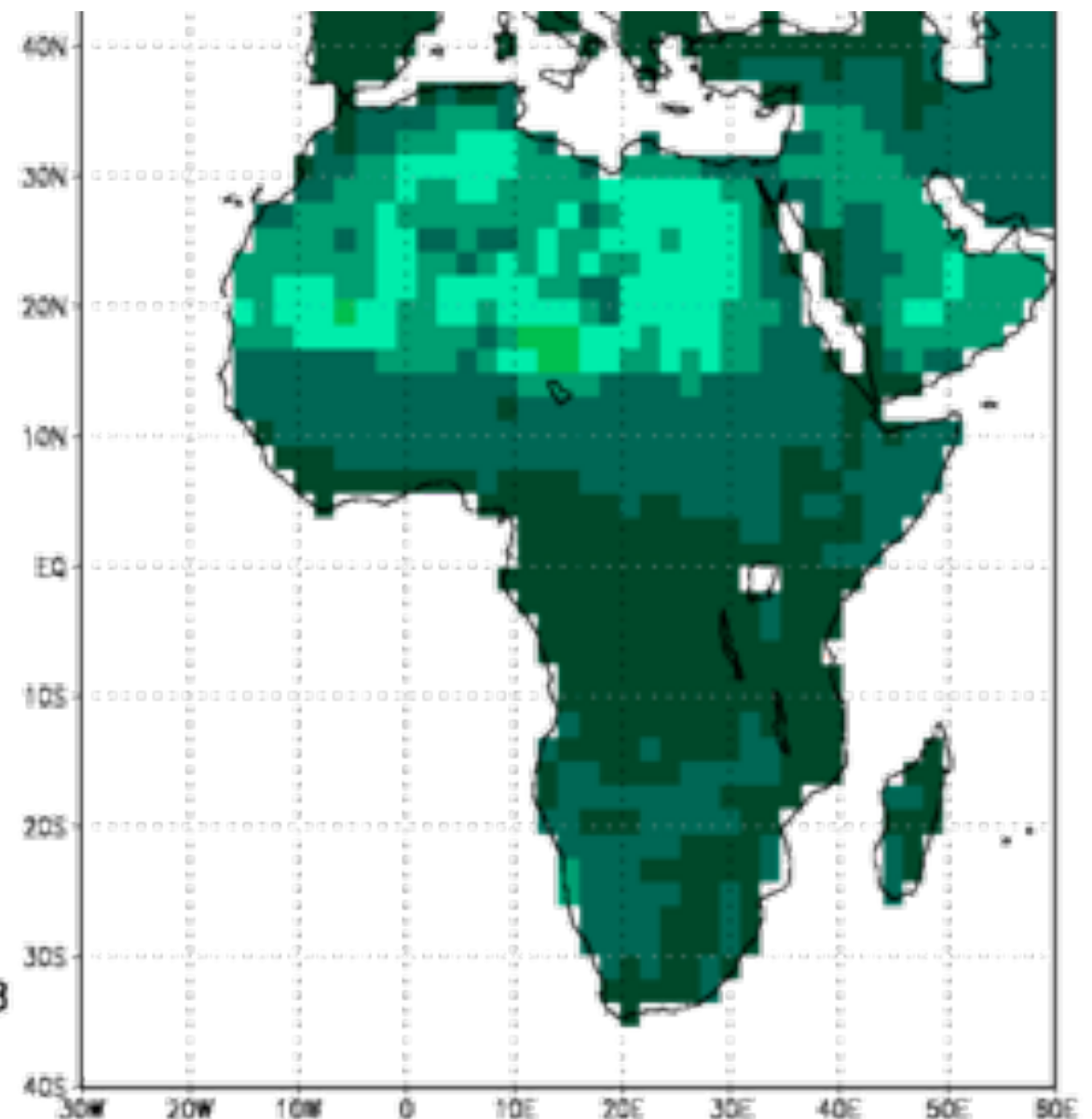
Annual cycle of albedo
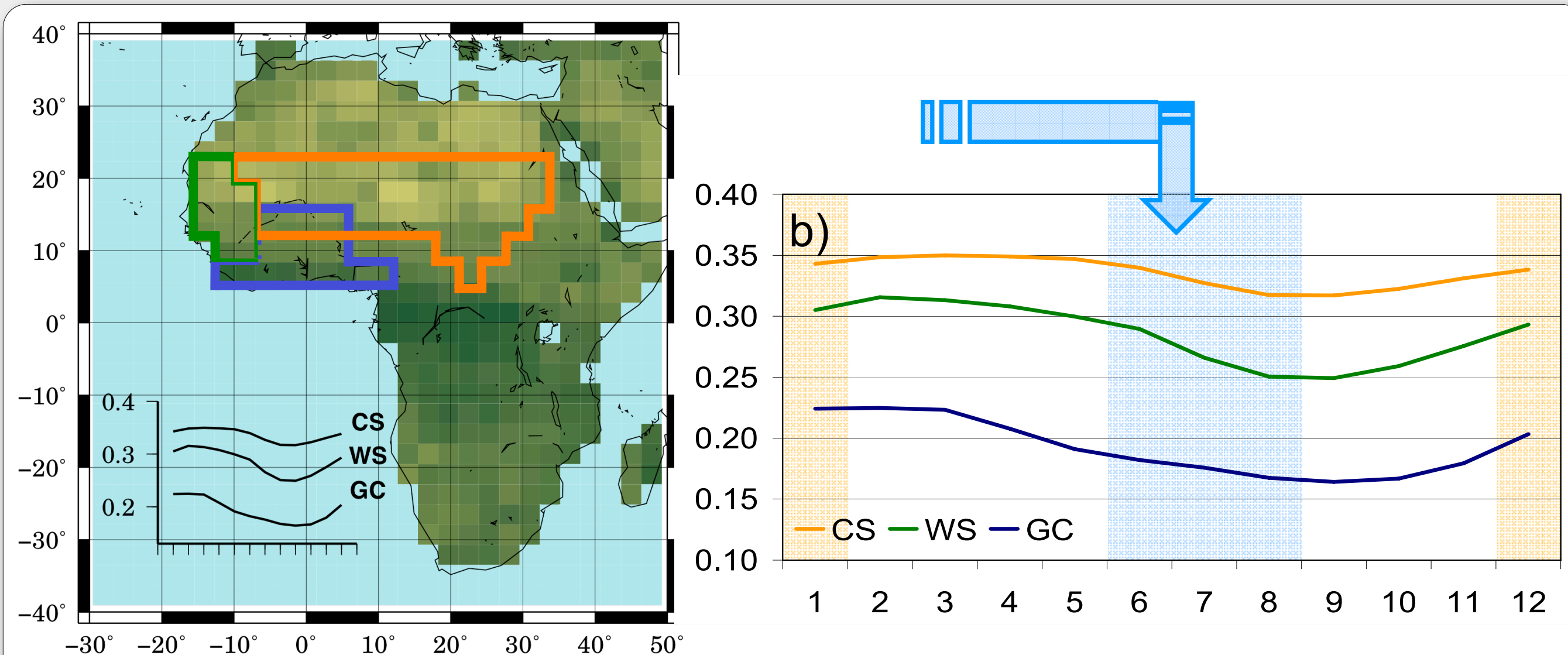
reproduction of albedo's annual cycle

observed mean June to August precipitation (1960-1999)
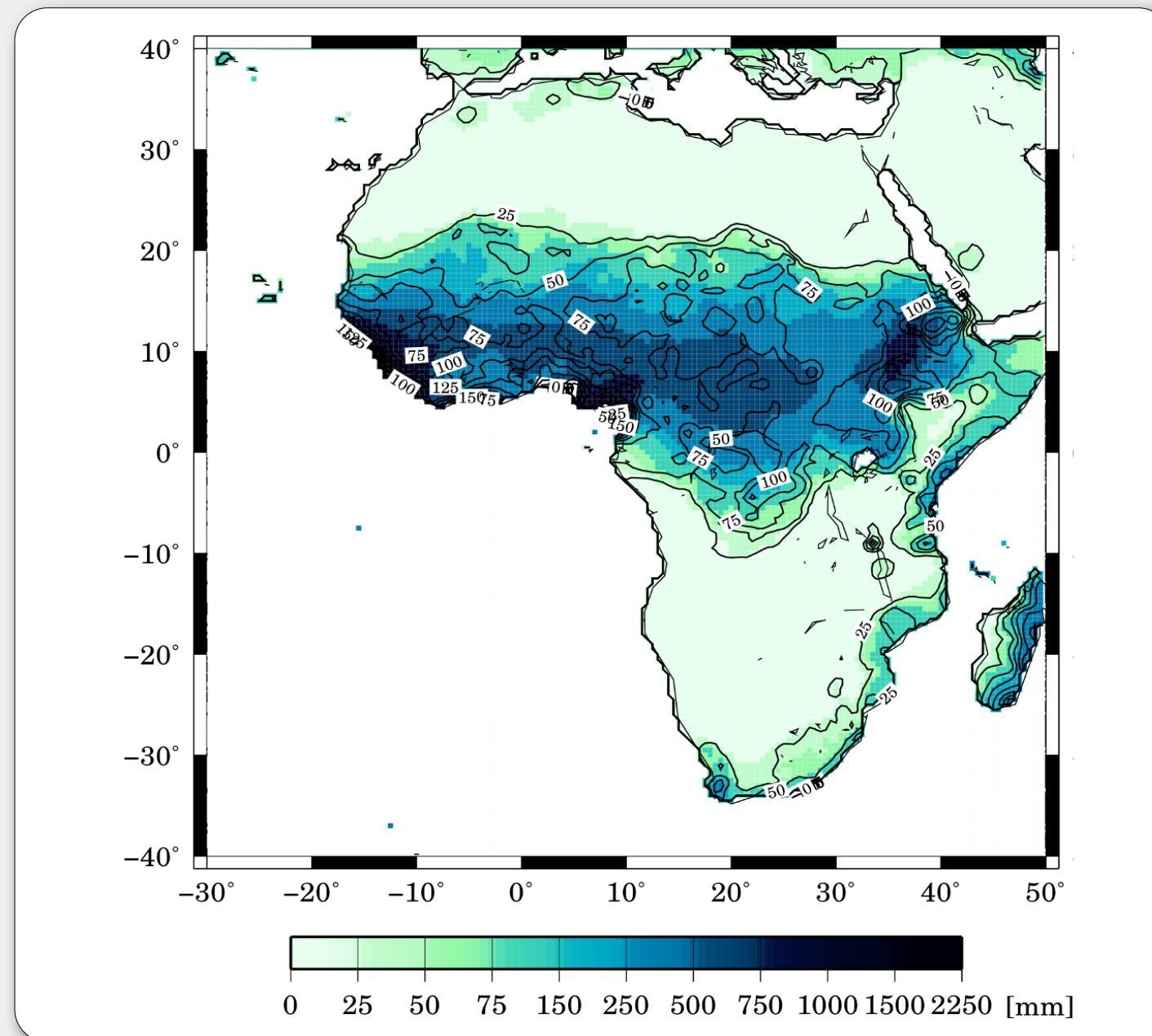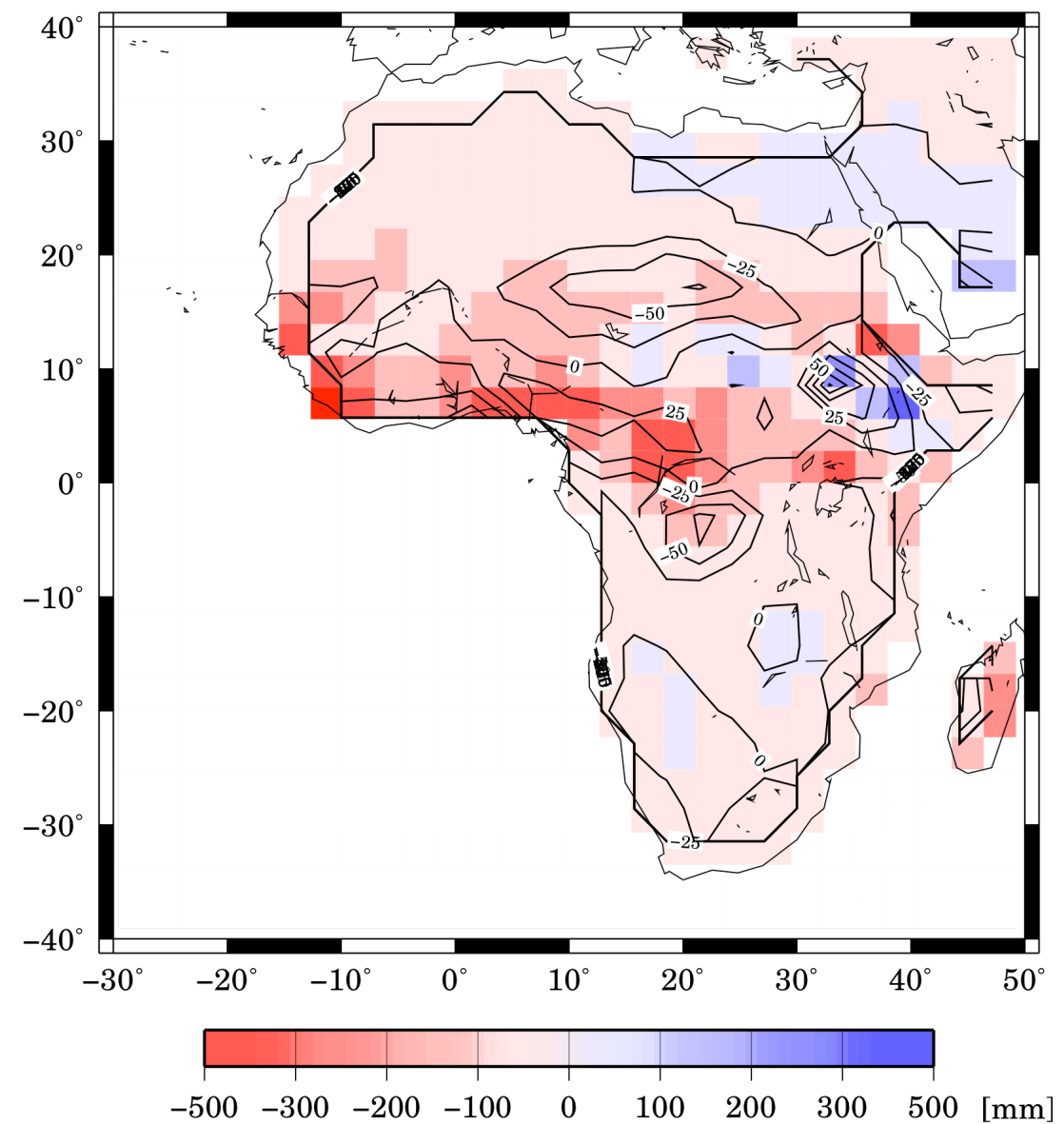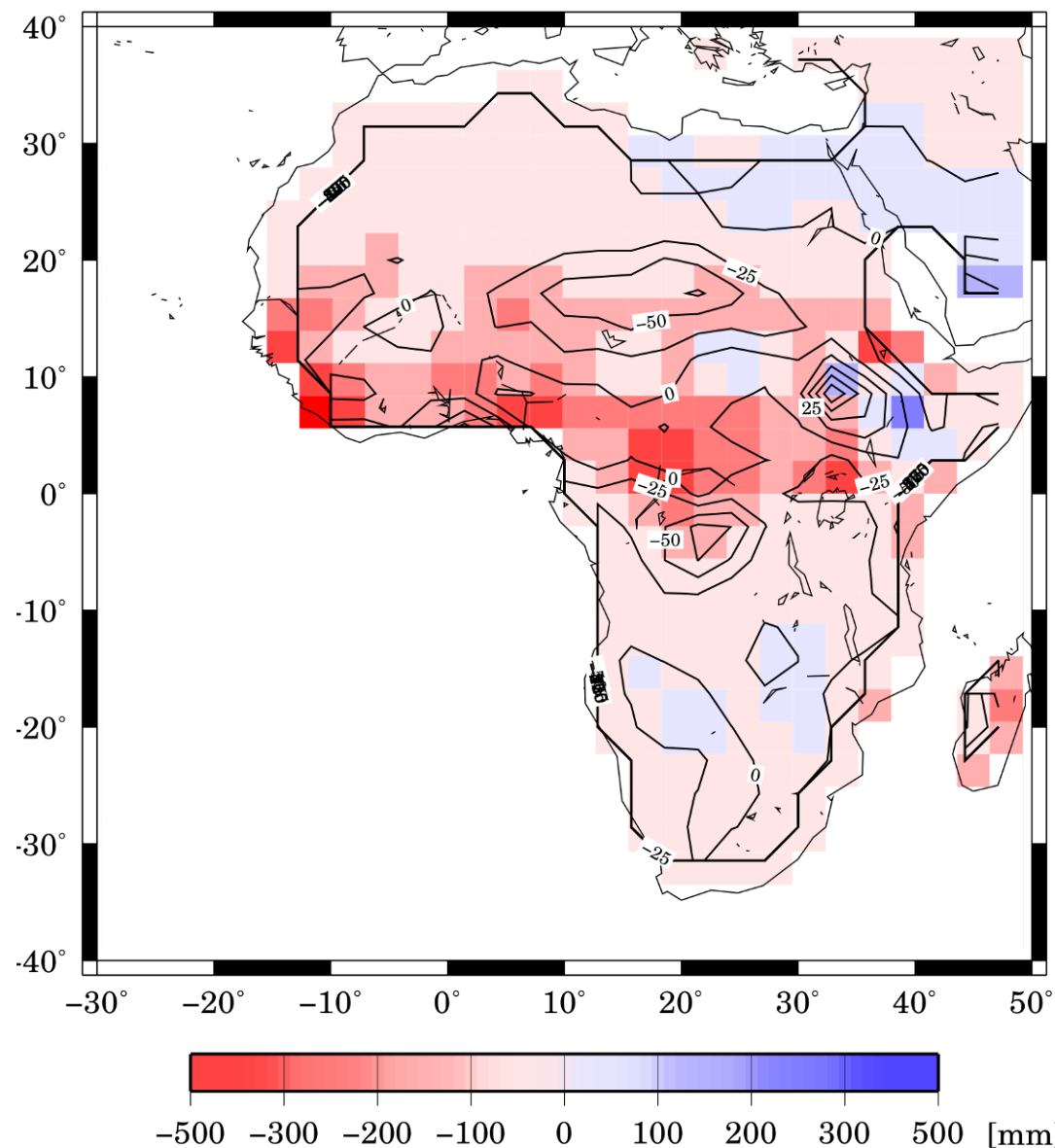
Differences in summer precipitation amounts (JJA)
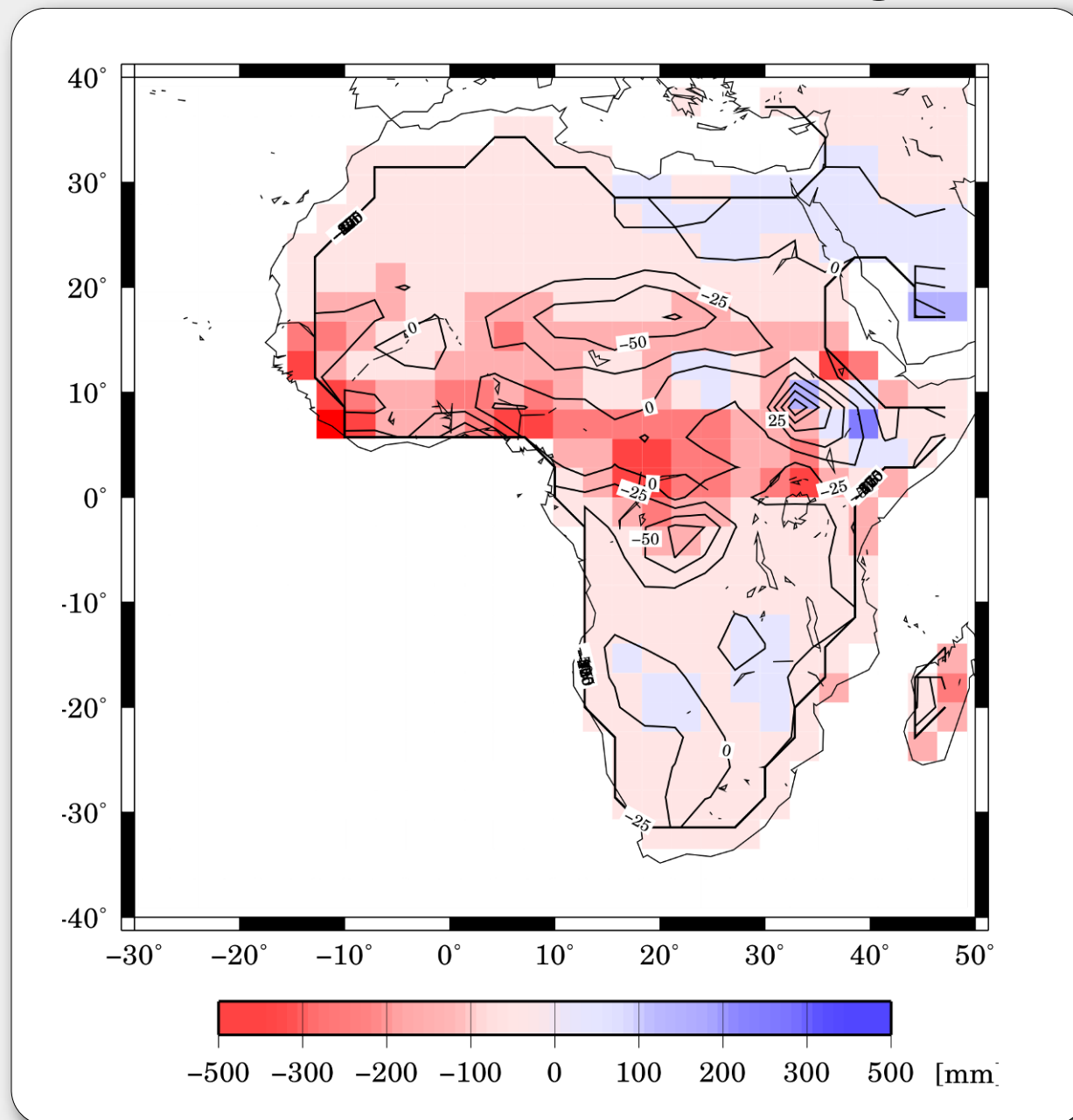
observations – E5 SVege

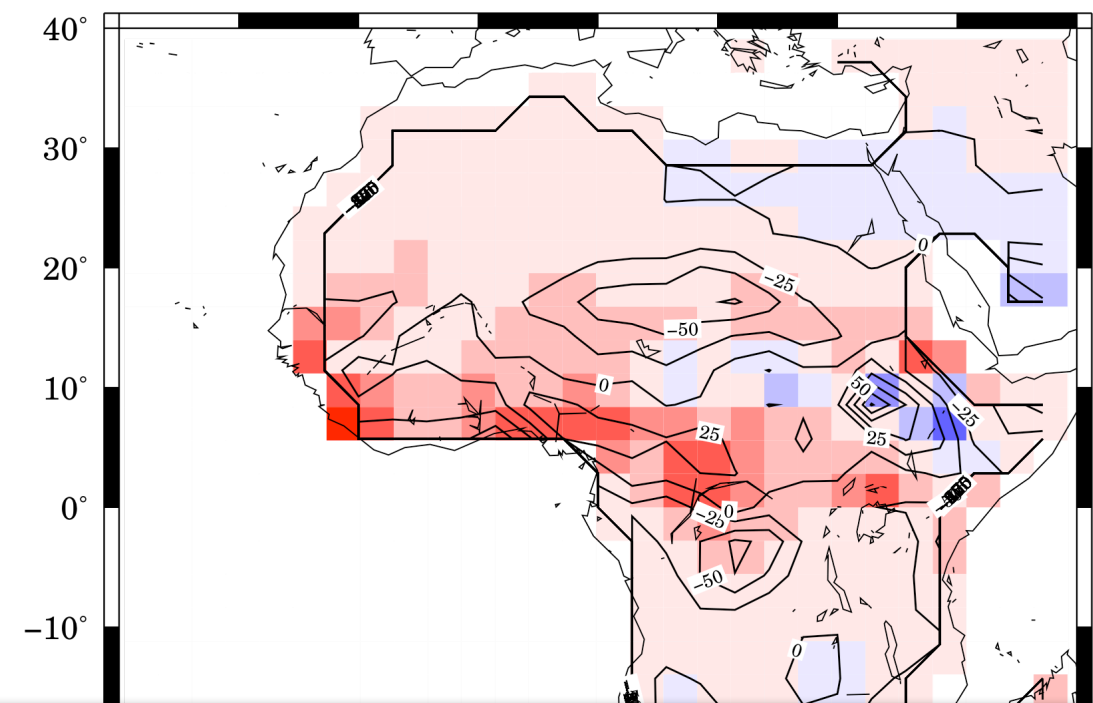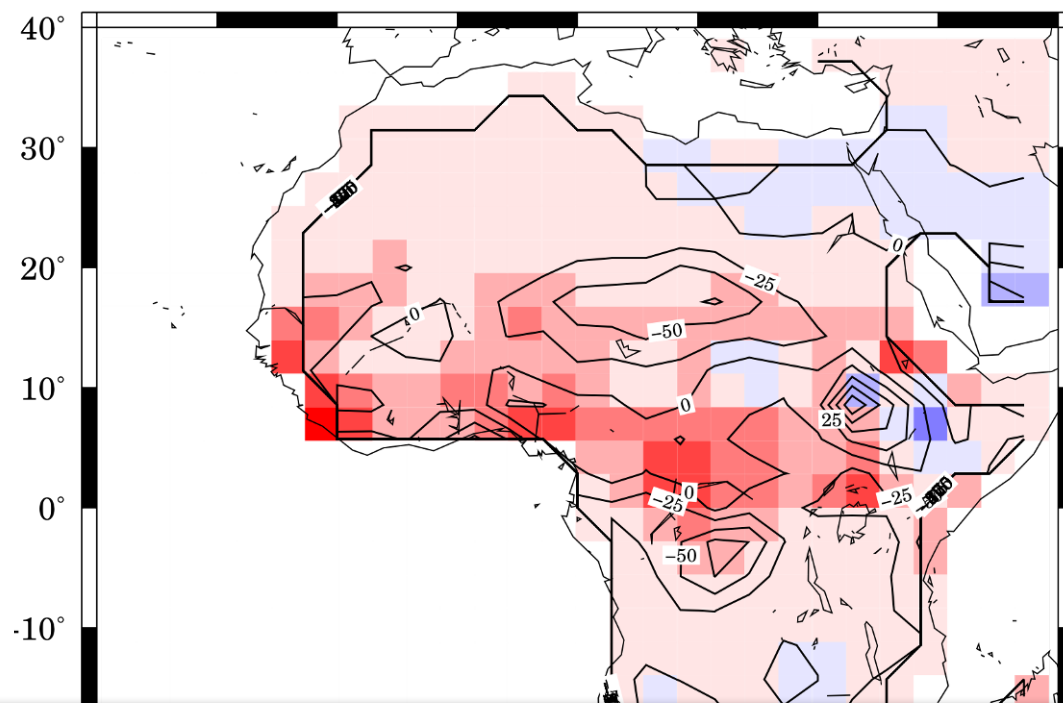# Differences in summer precipitation amounts (JJA)

observations − E5 SVege   observations − E5 original

Differences in summer precipitation amounts (JJA)

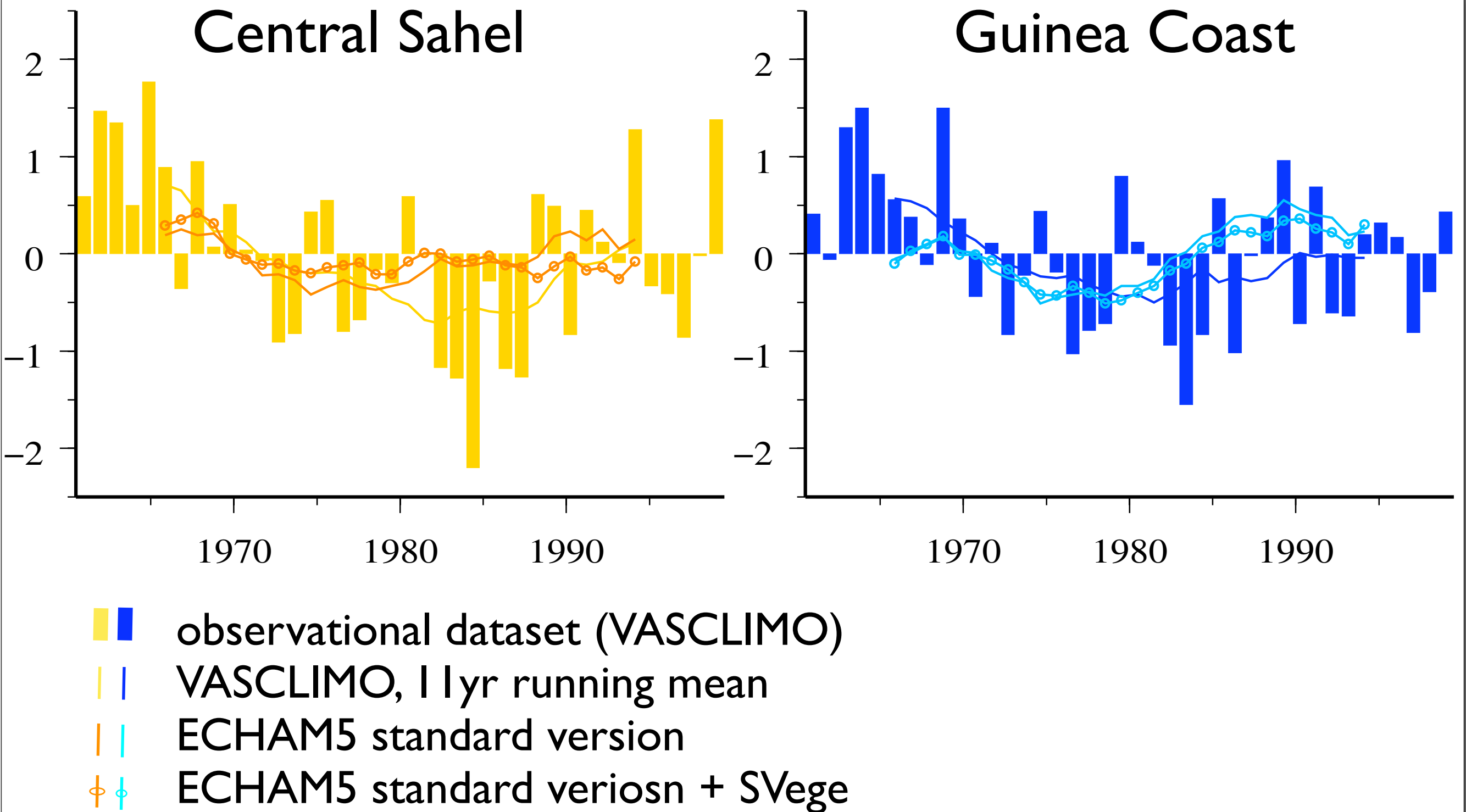observations − E5 SVege   observations − E5 original

- both versions comprise same strengths and deficiencies
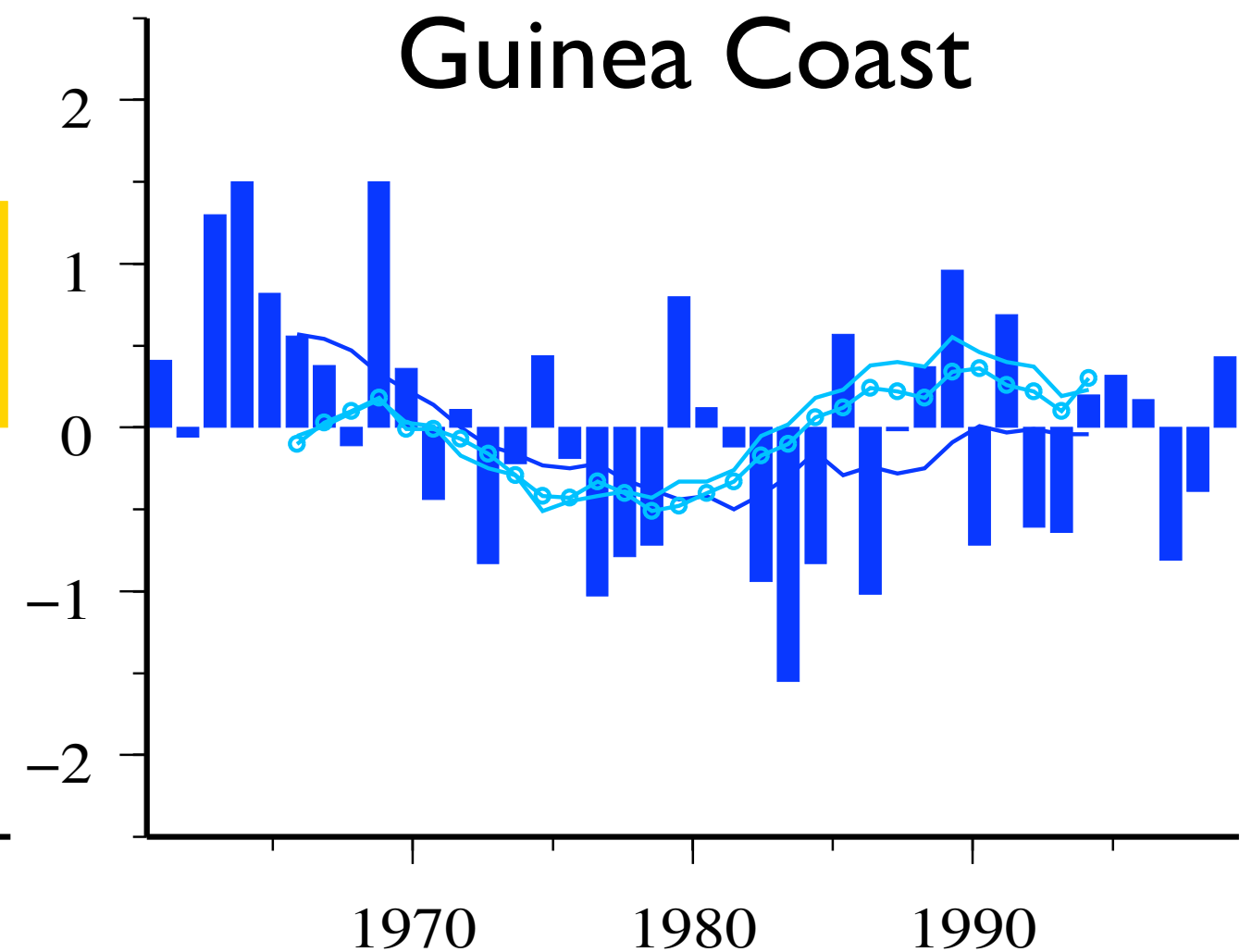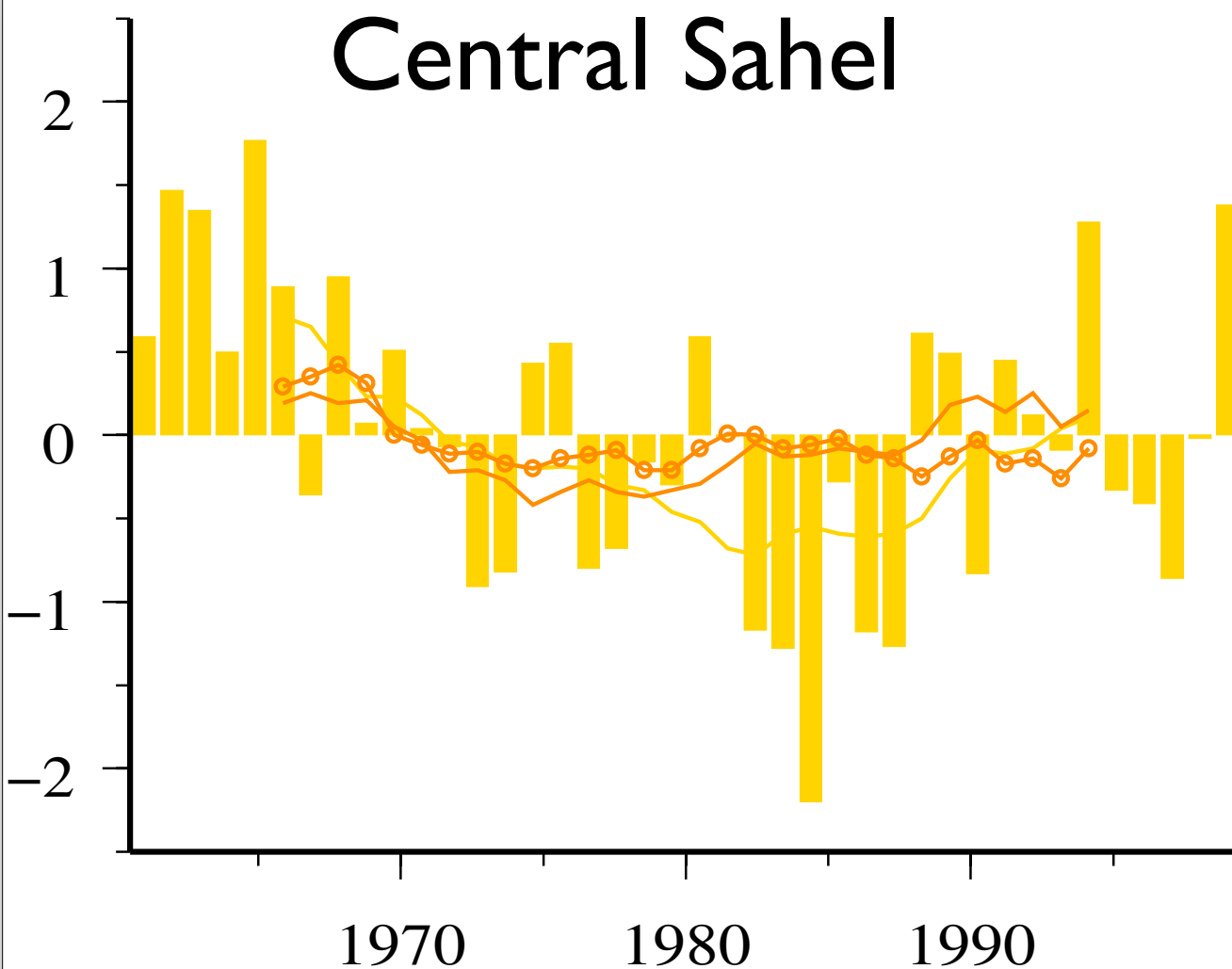- only small, insignificant differences between the model

decadal variability

Central Sahel

Guinea Coast

■ ■ observational dataset (VASCLIMO)
| | VASCLIMO, 11yr running mean
| | ECHAM5 standard version
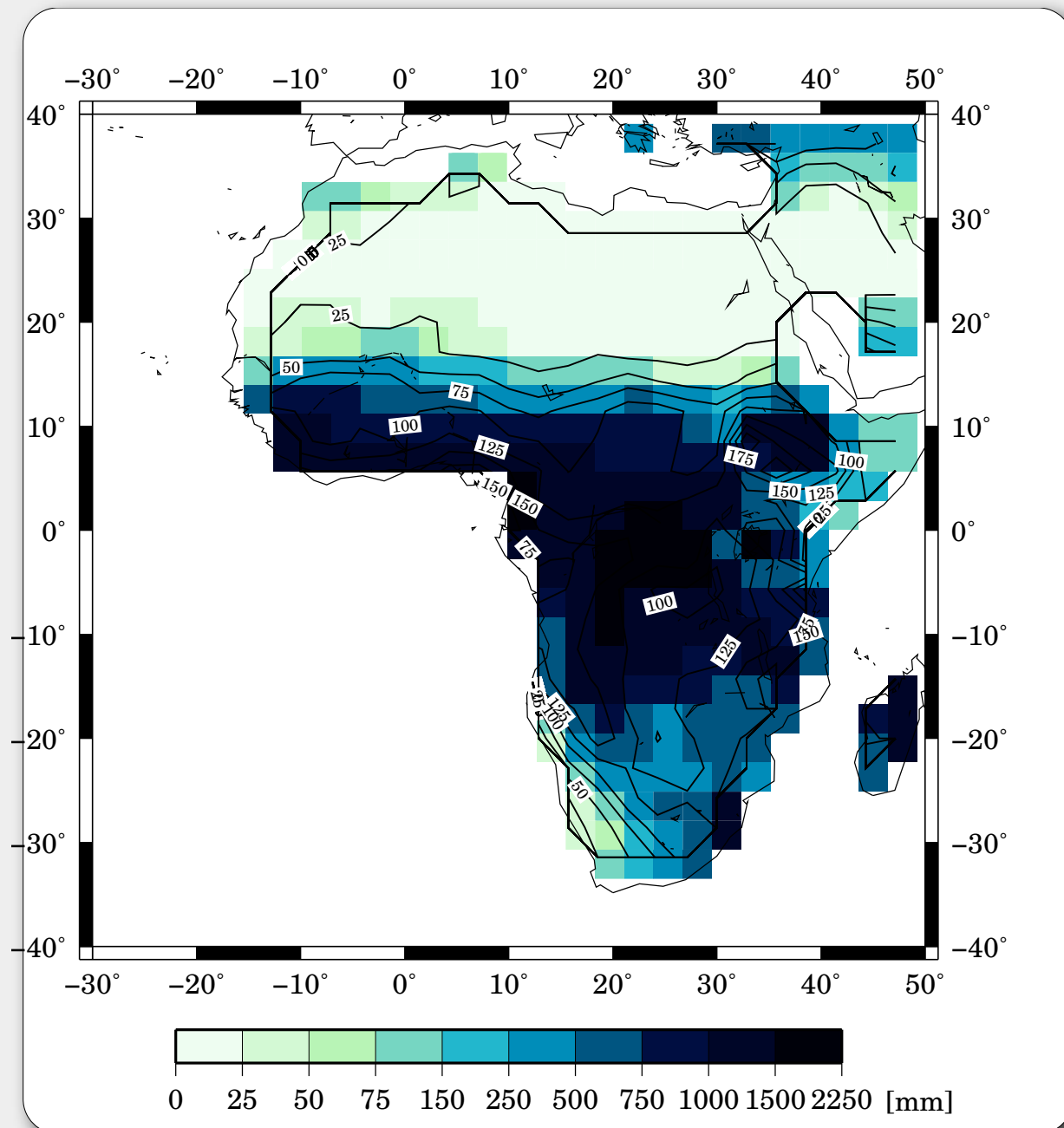⟟ ⟟ ECHAM5 standard veriosn + SVege

decadal variability
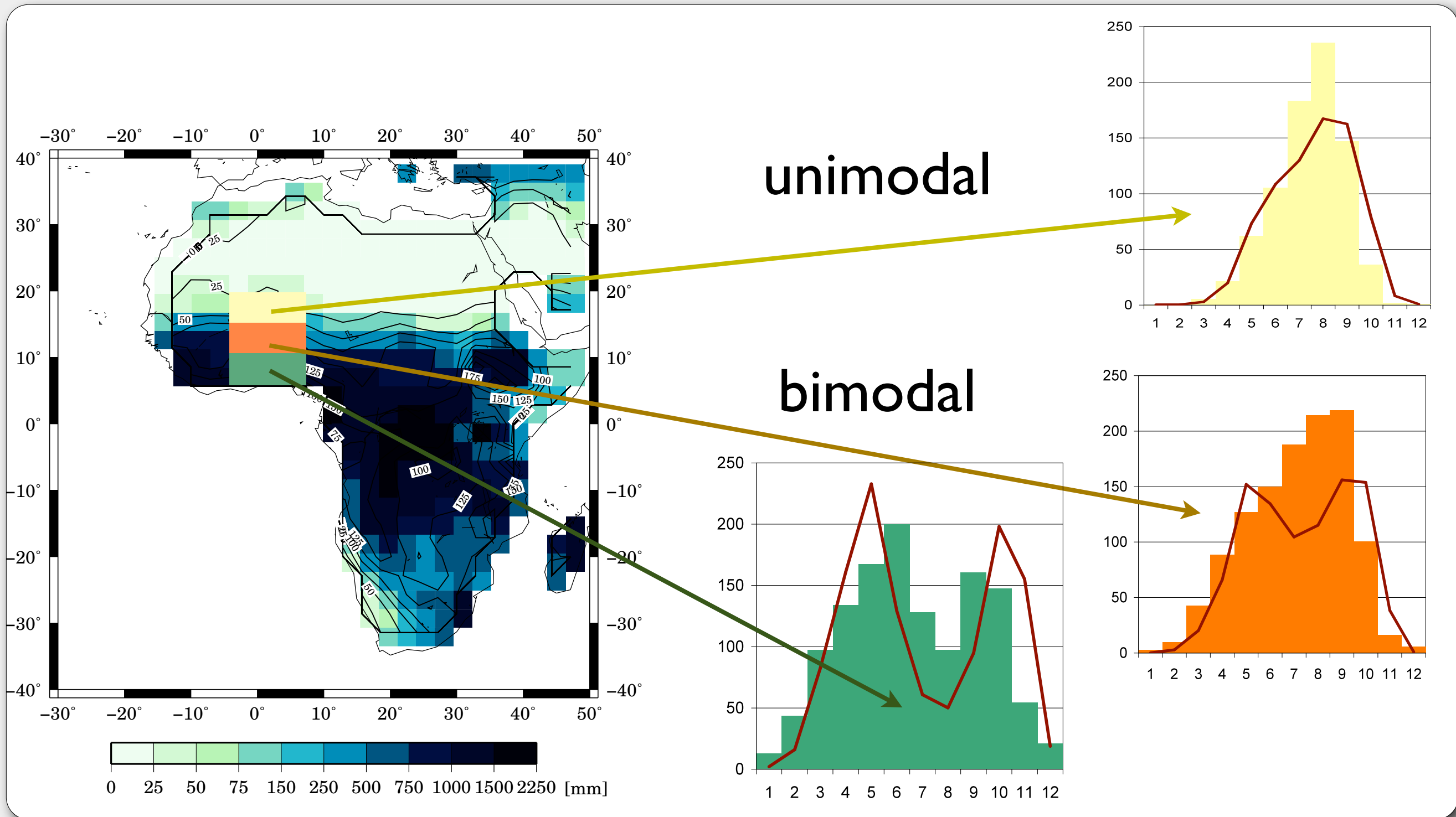

Central Sahel

Guinea Coast

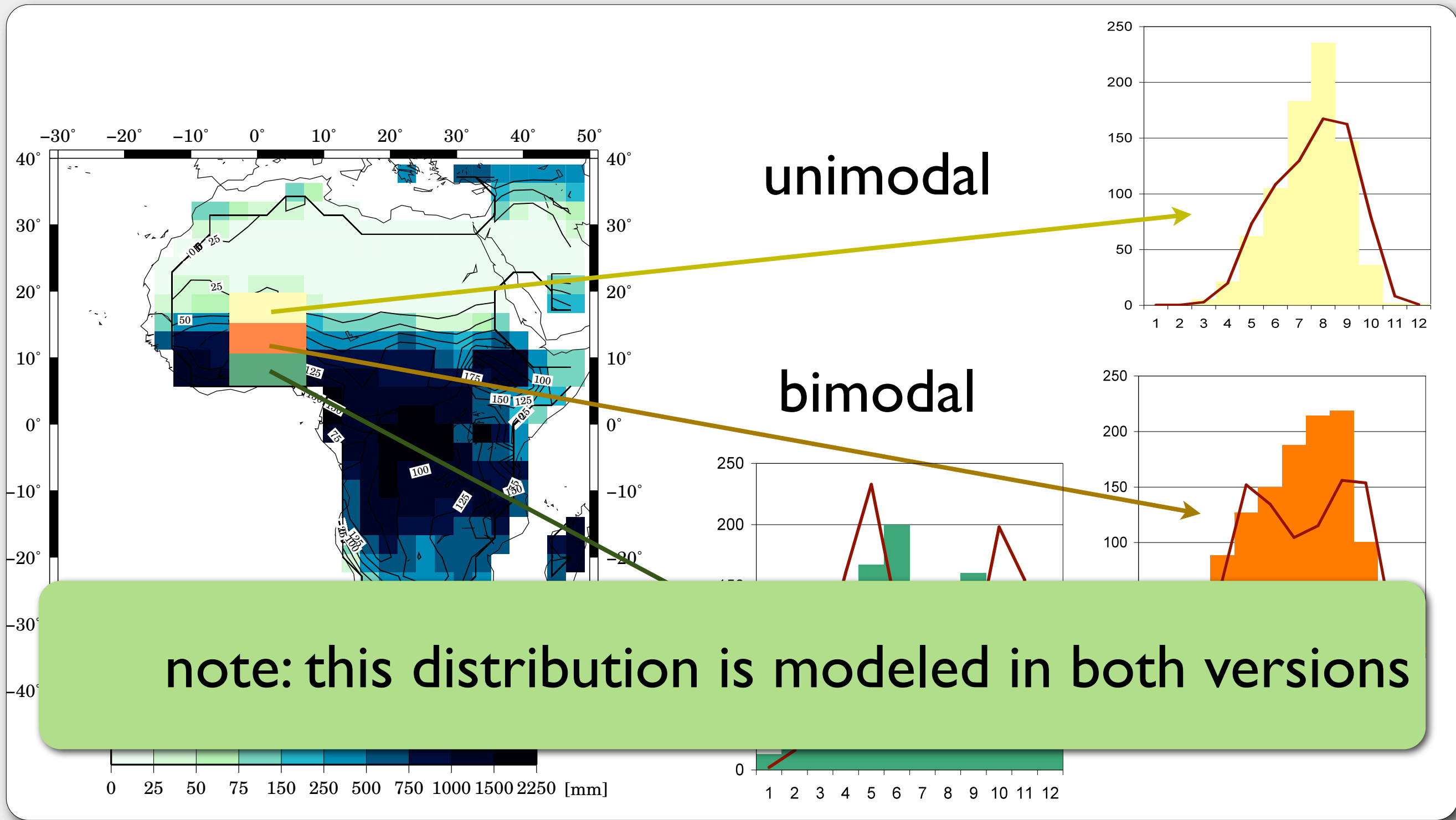significant changes to an higher correlation (up to 0.2) between model and observation using the vegetation model

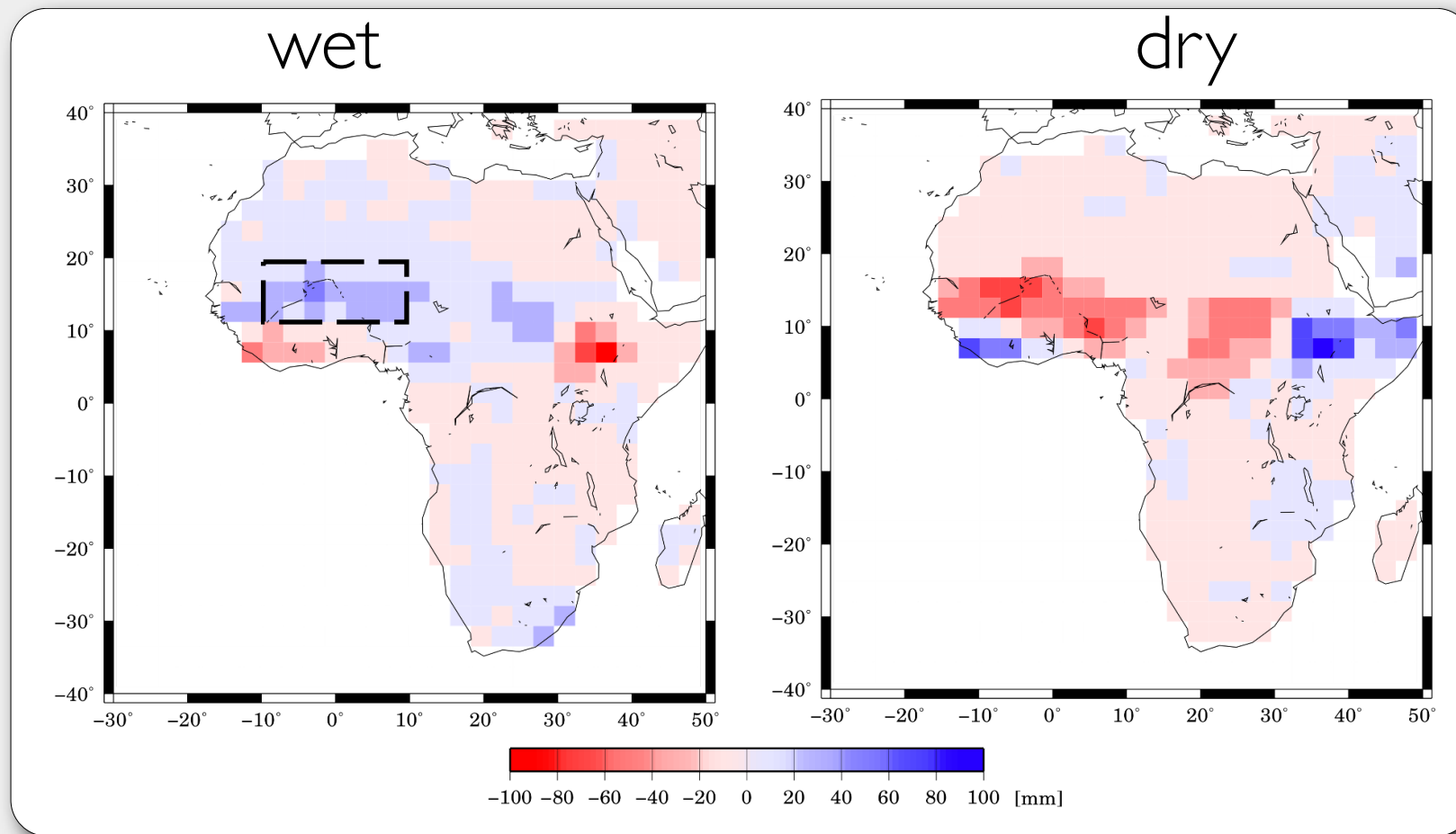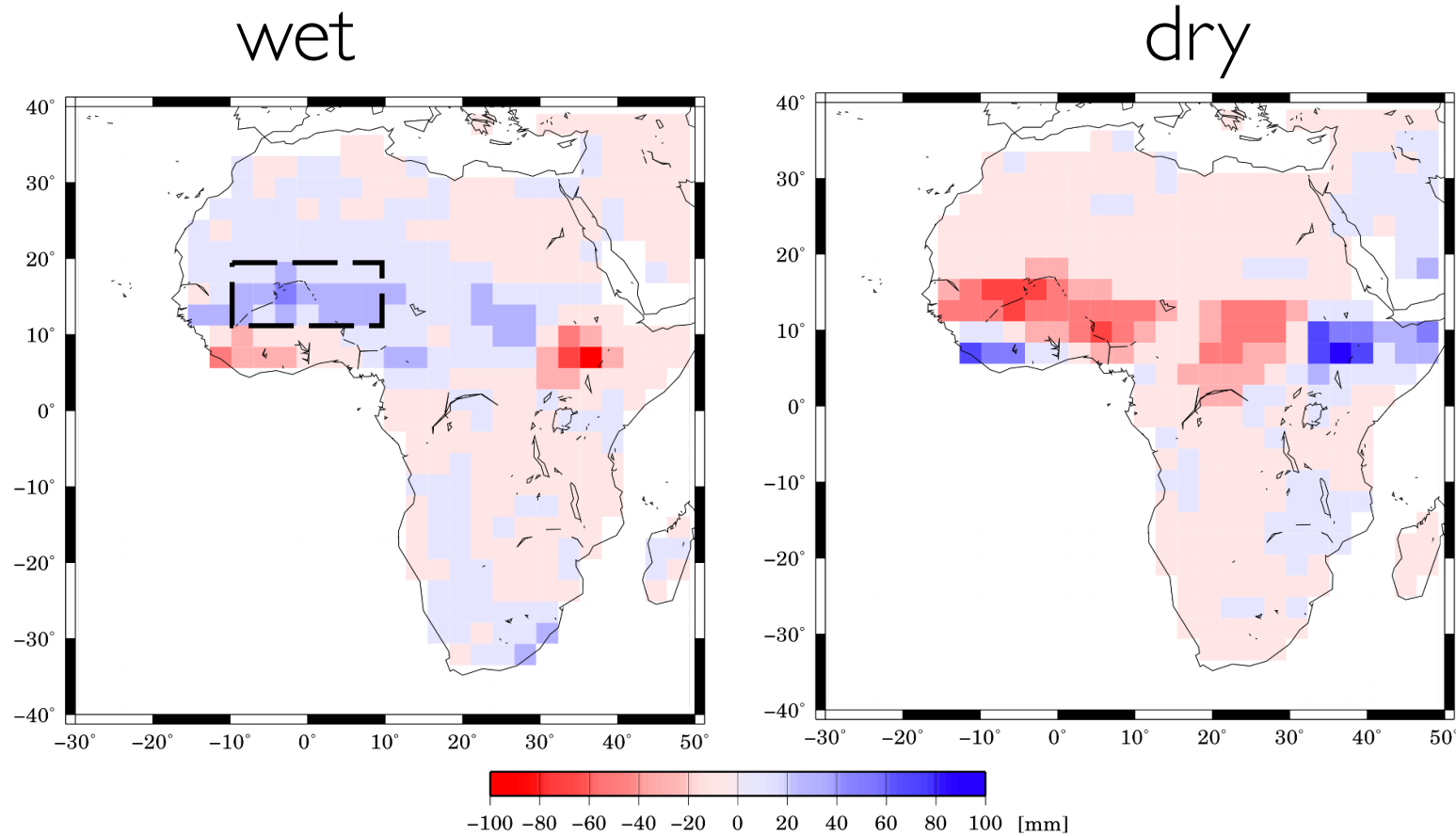# precipitation annual cycle

precipitation annual cycle

unimodal

bimodal

precipitation annual cycle

unimodal

bimodal

note: this distribution is modeled in both versions

about extreme dry and wet years

Central Sahel

about extreme dry and wet years
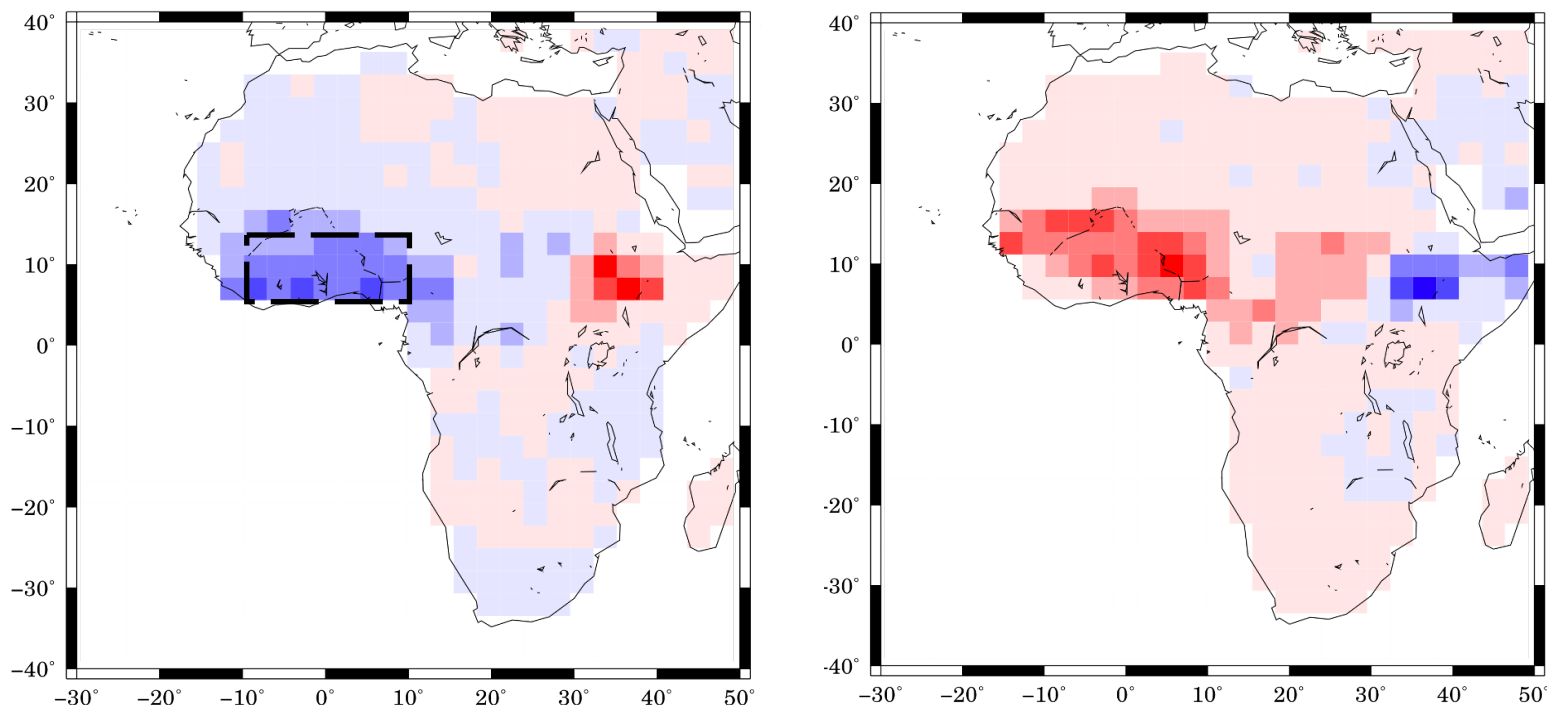
wet   dry

Central Sahel

Guinea Coast

−100 −80 −60 −40 −20 0 20 40 60 80 100 [mm]

differences between both versions in extreme dry and wet years
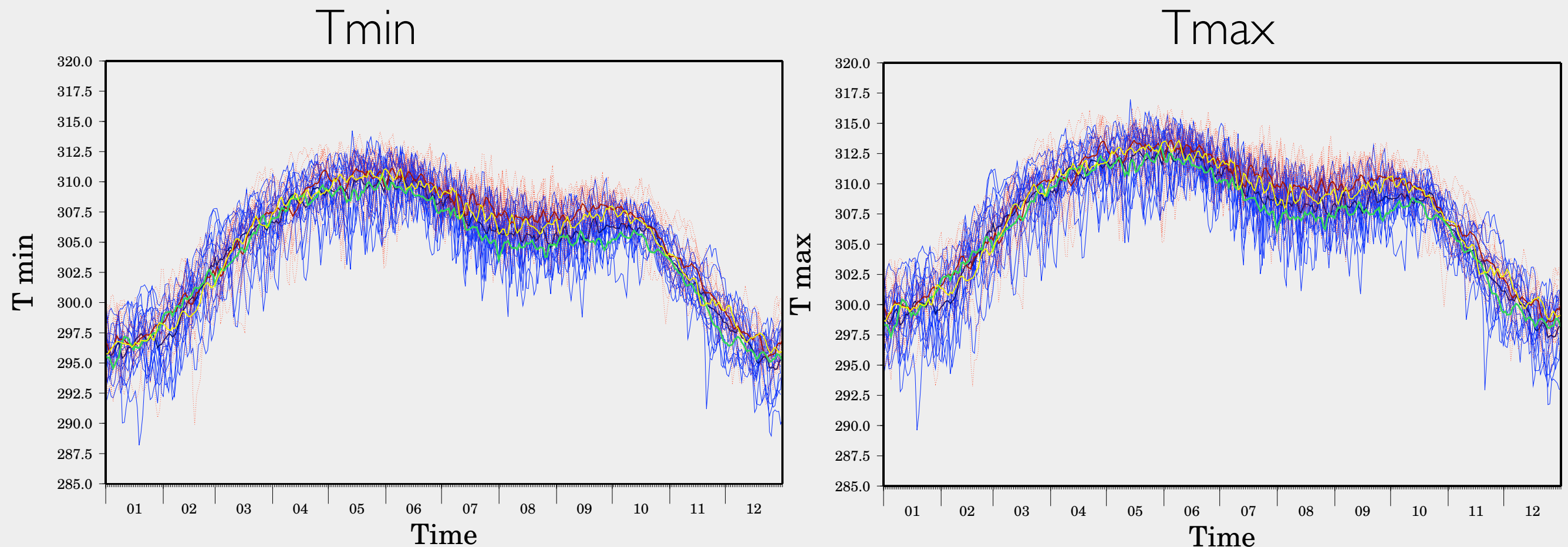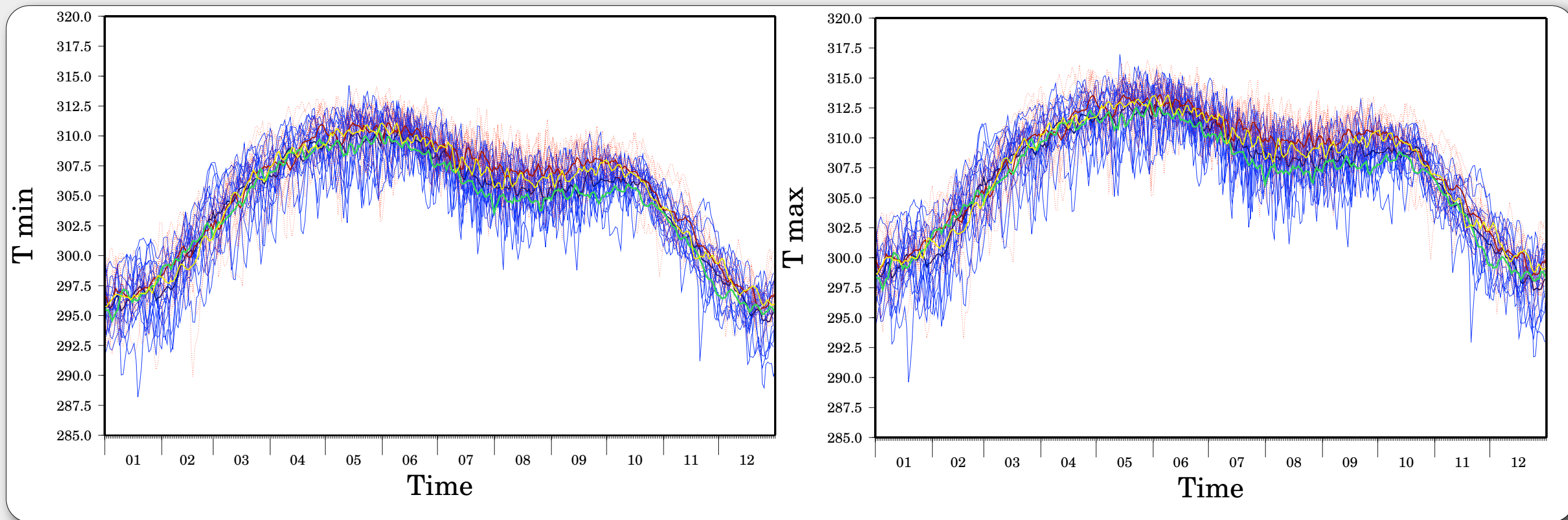

Central Sahel E5+SVege: ▌ wet years ▌ dry years

E5 original: ▌ wet years ▌ dry years

differences between both versions in extreme dry and wet years
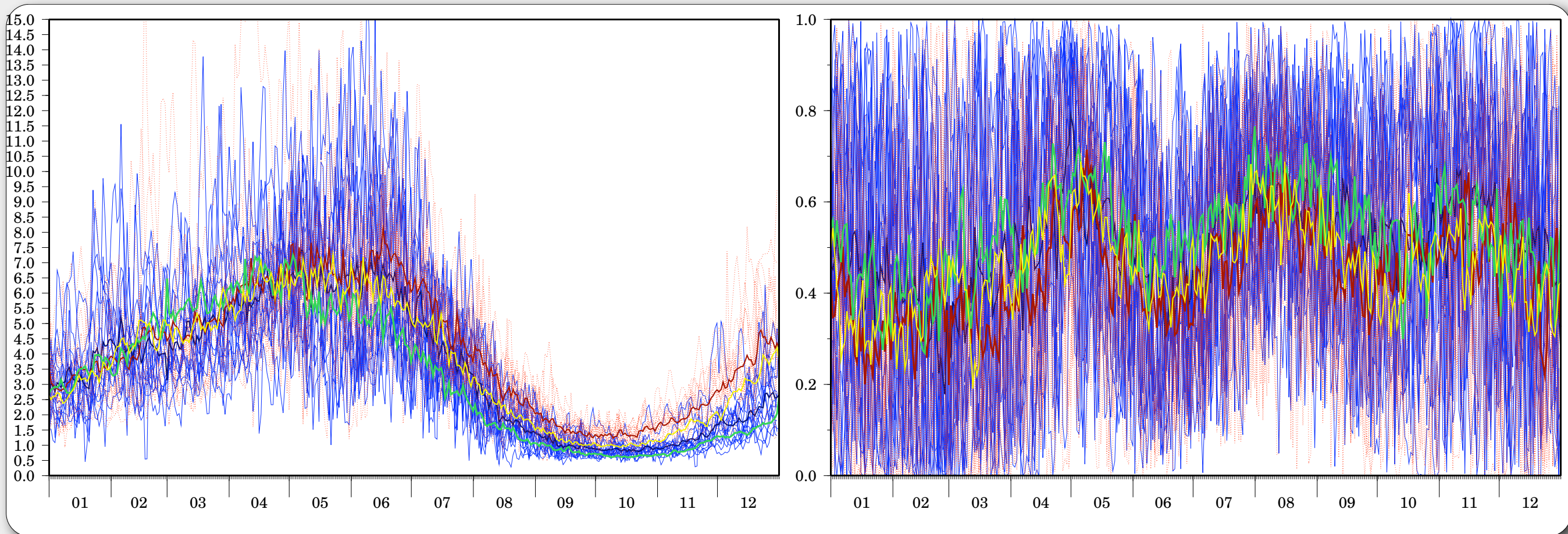

Central Sahel E5+SVege: ▌ wet years   ▌ dry years

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differences between both versions in extreme dry and wet years
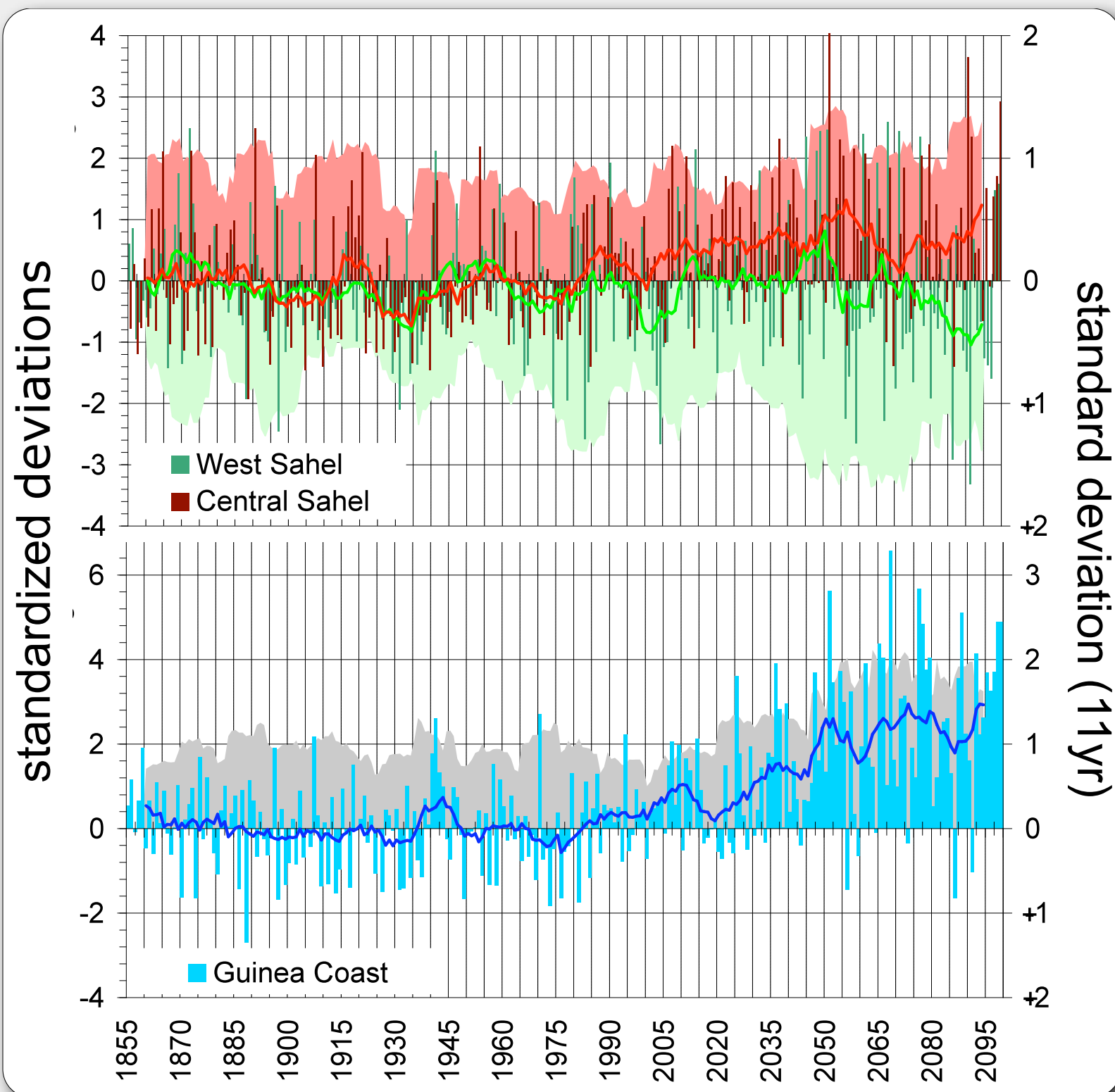
bowen ratio β

cloud cover

Central Sahel E5+SVege: ▌ wet years ▌ dry years

E5 original: ▌ wet years ▌ dry years
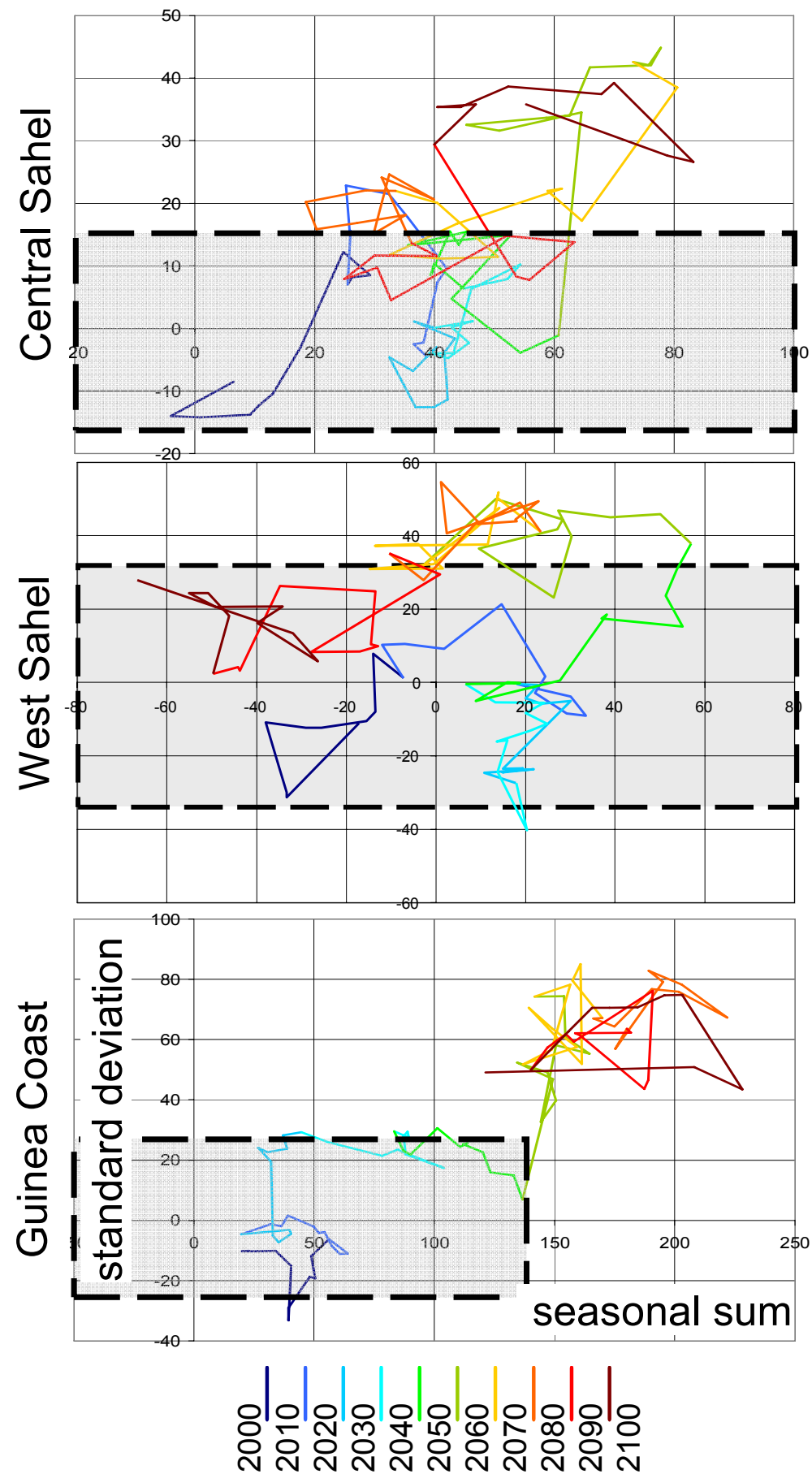
what about future trends ?

increasing variability (AIB)

- increasing standard deviation of the precipitation index
- increasing number of extreme seasons in the Sahel + Guinea Coast (wet and dry)
- decreases are projected for the Sahel using the B1-scenario

significance of changes (AIB)

phase diagram to show variability of standard deviation and mean values

conclusion

- implementation of biosphere to ECHAM5 using a simple vegetation approach (SVege)

  ➡ small, sometimes insignificant changes to standard version

  ➡ improved representation of decadal variability

  ➡ getting same results by a more physical based way

- the simple vegetation approach could be *to simple* for the sophisticated version of ECHAM5 ?

- COSMOS-Earth System Model (ESM); MPI-Hamburg, available in August / September (?)
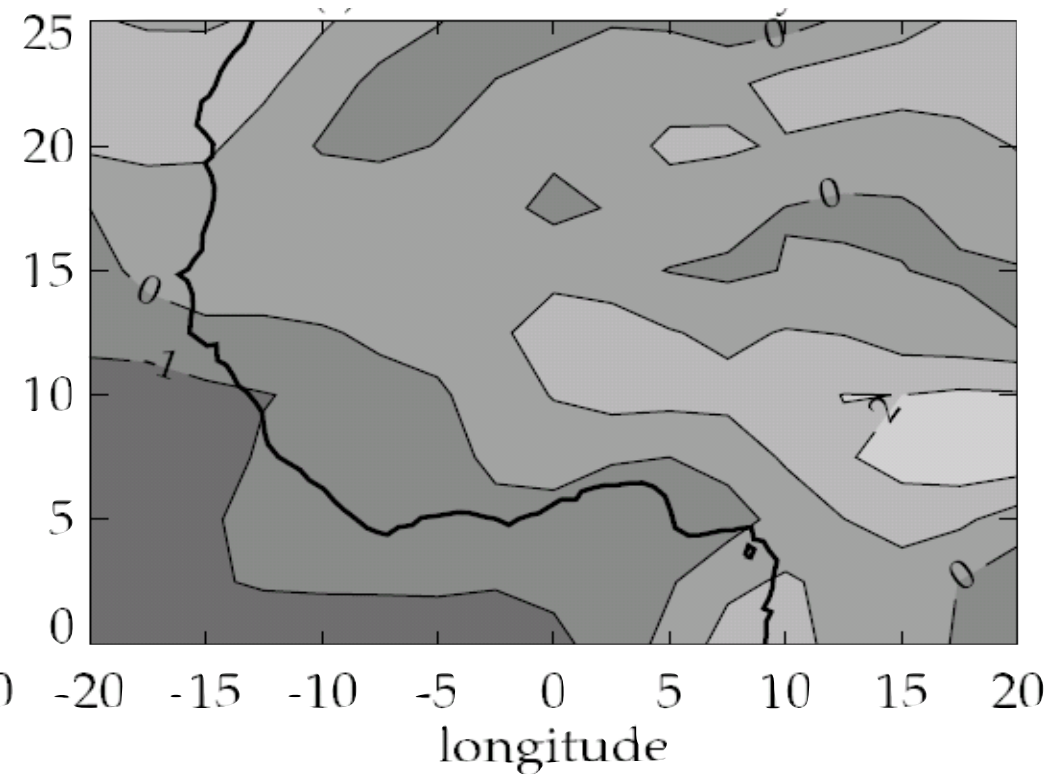
ideas for future work

- „testing" the model in comparison to other WAMME experiments
- improvement by using another aerosol climatology (A. Tompkins)
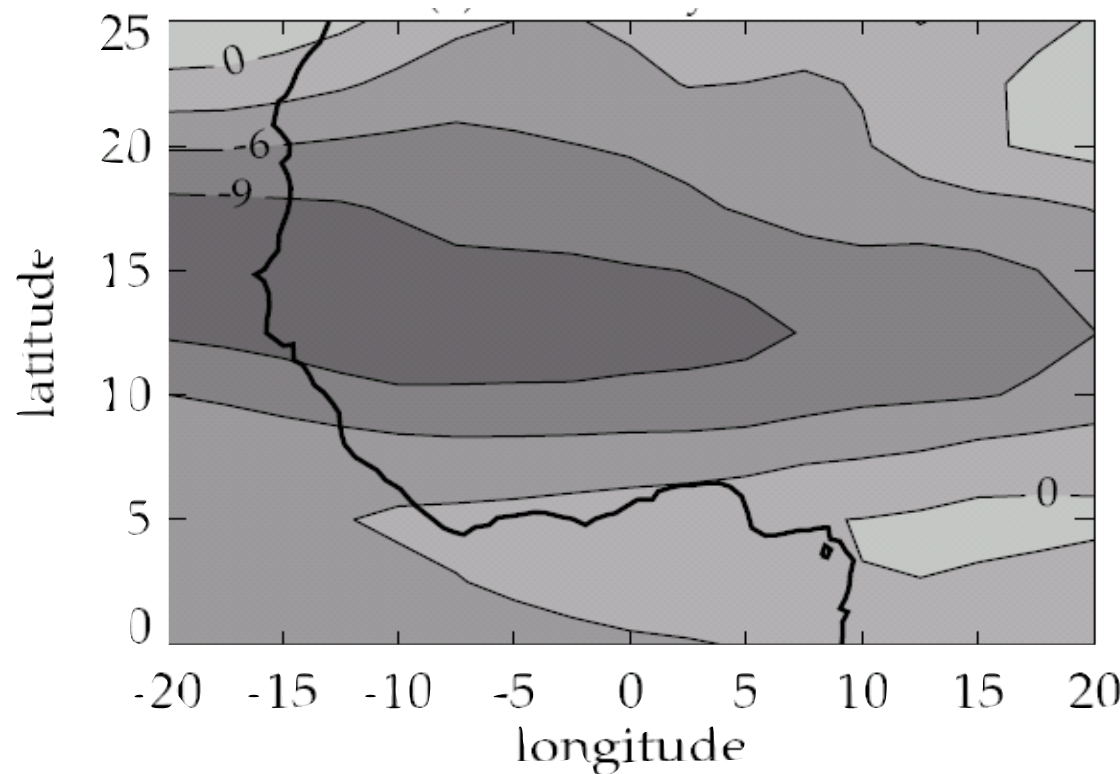
Tanre (1984)   Tegen (1997)

5d forecast for windspeed at 700 hPa

thanks for your interest